Brent Wiley, Editor
James D. Kelly, Advertising Mgr.

BOARD OF DIRECTORS
1936 • 1937

▲

PRESIDENT,
H. G. R. BENNETT.
Assistant
General Superintendent,
Carnegie-Illinois Steel
Corporation,
Duquesne, Pa.

1ST VICE PRESIDENT, L. F. COFFIN, Superintendent Mechanical Department, Bethlehem Steel Co., Sparrows Point, Md.

2ND VICE PRESIDENT, C. C. WALES, Chief Engineer, Otis Steel Co., Cleveland, Ohio.

DIRECTOR AT LARGE, C. L. McGRANAHAN, Assistant General Superintendent, Jones & Laughlin Steel Corp., Pittsburgh, Pa.

HONORARY DIRECTOR, JAS. FARRINGTON, Electrical Superintendent, Wheeling Steel Corp., Steubenville, Ohio.

HONORARY DIRECTOR, E. FRIEDLANDER, Pittsburgh, Pa.

PAST PRESIDENT, G. R. CARROLL, Electrical Superintendent, Jones & Laughlin Steel Corp., Aliquippa, Pa.

PAST PRESIDENT, W. H. BURR, Electrical and Mechanical Superintendent, Lukens Steel Co., Coatesville, Pa.

TREASURER, F. E. FLYNN, Gen. Mgr., Warren District, Republic Steel Corp., Warren, Ohio.

SECRETARY, J. L. MILLER, Assistant Combustion Engineer, Republic Steel Corp., Cleveland, Ohio.

DIRECTOR, J. W. BATES, Electrical Engineer, Power Division, Carnegie-Illinois Steel Corp., Pittsburgh, Pa.

DIRECTOR, C. C. PECU, Lubrication Engineer, Bethlehem Steel Co., Lackawanna, N. Y.

DIRECTOR, M. J. CONWAY, Fuel Engineer, Lukens Steel Co., Coatesville, Pa.

DIRECTOR, J. A. CLAUSS, Chief Engineer, Great Lakes Steel Corp., Ecorse, Mich.

DIRECTOR, H. G. HAGUE, Electrical Superintendent, Carnegie-Illinois Steel Corp., Gary Sheet Mill, Gary, Indiana.

DIRECTOR, G. N. HUGHES, Electrical Superintendent, Gulf States Steel Co., Alabama City, Ala.

DIRECTOR, F. E. LEAHY, Fuel Engineer, Youngstown Sheet & Tube Co., Youngstown, Ohio.

DIRECTOR, W. A. PERRY, Superintendent, Electrical and Power Departments, Inland Steel Company, Indiana Harbor, Ind.

DIRECTOR, R. G. ADAIR, Asst. Director of Industrial and Public Relations, American Rolling Mill Co., Middletown, Ohio.

▲

MANAGING DIRECTOR
BRENT WILEY
Empire Building, Pittsburgh, Pa.

IRON AND STEEL ENGINEER

VOL. XIV JULY • 1937 NO. VII

CONTENTS

Mechanical Developments of Modern Cold Rolled Strip Mills—by John L. Young, Manager Machinery Sales, United Engineering & Foundry Company, Pittsburgh, Pa. 19

Electrical Operation of Cold Strip Mills—by A. F. Kenyon, Steel Mill Engineer, Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa. 27

The Measurement of the Frictional Characteristics of Brushes—by Dr. S. W. Glass, Research Laboratories, National Carbon Company, Inc., Cleveland, Ohio 39

Fundamentals of Safety and Accident Prevention in Steel Plants—by L. H. Burnett, Vice President, Carnegie-Illinois Steel Corporation 43

New Continuous Rod Mills, American Steel and Wire Company, Joilet, Illinois 50

Latest Design and Equipment For The Industry 53

Items of Interest 58

Review of Inspection Trip to Carnegie-Illinois' New Plate Mill at Homestead, Pennsylvania 5

New Members 7

Index to Advertisers 11

Association Activities 14

Published Monthly by
ASSOCIATION OF IRON AND STEEL ENGINEERS
Entered as second-class matter January 25th, 1924, at Pittsburgh, Pa., under the Act of March 3rd, 1879. Single Copy $1.00
Subscription price in U. S. & Canada ..... $5.00 per year
Subscription price in foreign countries ..... $7.50 per year

PLASTIC BINDING U. S. PATENT NO. 1970285 LICENSE NO. 38

Three of an installation of seven Westinghouse motors which coil hot steel strip at mill speed. Two of the rolls which they drive are stationary, five swing outward as the coil gets larger. Two additional motors of the same type are used to drive pinch rolls.

WINDING STEEL STRIP *LIKE PAPER*

with Westinghouse Coiler Motors

Heat generated within this 51 hp. Westinghouse motor is dissipated to the outside by means of an effective heat exchanger. The internal cooling air passes through ducts in the stator adjacent to external air ducts, through which air is constantly blown by a fan on the motor shaft.

Taking a strip of hot steel a fifth of a mile long and converting it into a roll five feet in diameter in less than a minute is the job of seven Westinghouse type CS coiler motors. Rated at 15 horsepower, these motors must accept the strip continuously at mill speed, and when the coiling is completed, bring it, by dynamic braking, to a quick stop for unloading.

Adding to this severe duty cycle, the motors operate in an atmosphere laden with dirt, moisture, heat, and fumes. Also, the motors must be of unusually small diameter, because, when the coil is started, the rolls are tangent to a 30-inch circle.

Westinghouse dual-ventilated fan-cooled motors, with their heat-exchanger principle of cooling, eliminate the need for water cooling. Needless to say, heat-proof mica and asbestos insulation are used for the motor windings.

Problems such as this are being solved regularly by Westinghouse engineers. For their assistance, call or write the nearest Westinghouse Office. J 93234

Westinghouse

WESTINGHOUSE ELECTRIC

REVIEW OF INSPECTION TRIP TO NEW PLATE MILL AT HOMESTEAD

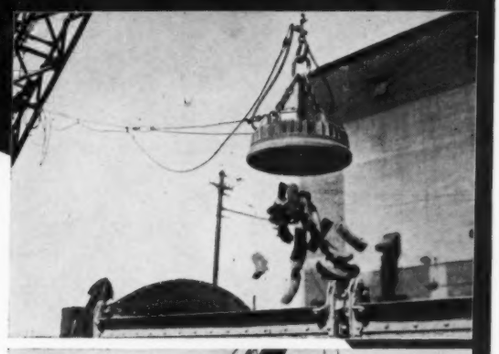
Over 400 members and guests of the Association inspected the new 100″ semi-continuous plate mill of the Carnegie-Illinois Steel Corporation, Homestead, Pa., on June 23. The party was transported in chartered buses from the William Penn Hotel directly to the plate mill. Special guides furnished by the Carnegie-Illinois Corporation met the buses and escorted the group through the mill.

Following the inspection trip an informal dinner was held in the William Penn Hotel. Immediately after the dinner the Pittsburgh Section of the Association concluded its season with a symposium on "Flood Control and Rehabilitation".

The accompanying illustrations tell the complete story of the day's activities.

Fast Handling Methods

Big Lifts—Quick Releases

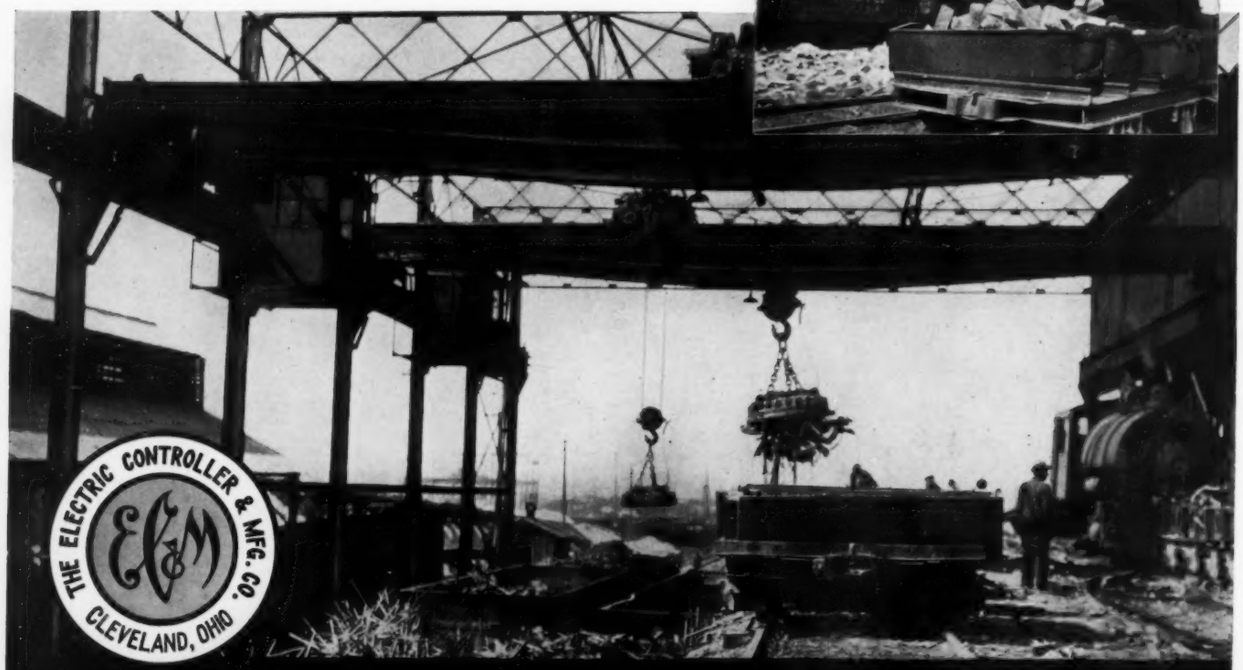


• The Lifting Magnet Method is an excellent means for handling scrap or pig iron, castings, finished products, etc., because it not only moves large quantities of material in a short time and at low cost, but it also performs tasks that are too dangerous or difficult to do by other means.

• Look at these illustrations of EC&M Lifting magnets at work, for example. There's no waiting for hook-on men. No chains to slip . . . or to damage polished surfaces. In addition, the Lifting Magnet can be used, when necessary, for 24-hour handling service.

• And in recent years, many New Magnets are replacing ones of older design. Users find that faster handling of materials with New Magnets permits a saving that returns the cost of the original investment in a very short time. Ask for a copy of Bulletin 900 which describes these efficient, material-handling tools.

• THE ELECTRIC CONTROLLER & MFG. COMPANY, 2670 East 79th Street, Cleveland, Ohio



EC&M LIFTING MAGNETS

ASSOCIATION OF IRON AND STEEL ENGINEERS

NEW MEMBERS

JAMES M. HILL,

Vice President and General Manager,
Empire Sheet and Tin Plate Company
Mansfield, Ohio.

HOWARD LOGAN DAWSON

Superintendent of Maintenance,
Carnegie-Illinois Steel Corp.
Edgar Thomson Works,
Braddock, Penna.

HARVEY DEMMON,

Superintendent of Maintenance,
Carnegie-Illinois Steel Corp.,
Farrell, Penna.

A. J. FISHER,

Fuel Engineer,
Bethlehem Steel Company,
Sparrows Point, Md.

C. F. BAKER,

District Manager,
Crocker-Wheeler Electric Mfg. Co.,
Buffalo, N. Y.

C. W. E. CLARKE,

Consulting Engineer,
United Engineers & Constructors, Inc.,
Philadelphia, Penna.

ELWOOD H. KOONTZ,

Sales Engineer,
Reliance Electric & Engineering Co.,
Philadelphia, Penna.

BERT R. HENDRICKSON,

Assistant Chief Engineer,
Carnegie-Illinois Steel Corp.,
Youngstown District,
Youngstown, Ohio.

JOHN M. DAVIS,

Supt. 11" Merchant and 12" Cotton Tie Mill,
Tennessee Coal, Iron and R. R. Co.,
Fairfield, Alabama.

E. W. LIND,

General Mill Foreman,
Tennessee Coal, Iron and R. R. Co.,
Fairfield, Alabama.

ATTE WIGLAMA,

Testing Engineer,
Carnegie-Illinois Steel Corp.,
Gary, Indiana.

A. E. LAPOE,

Central Engineer Manager,
Westinghouse Electric & Mfg. Co.,
Pittsburgh, Penna.

JOSEPH MALBORN,

Foreign Representative,
Davy & United Engineering Co., Ltd.
London, England.

H. LEE MOORE,

District Manager,
Buffalo Forge Company,
Pittsburgh, Penna.

WILLIAM REID,

General Manager,
Davy & United Engineering Co., Ltd.,
Sheffield, England.

H. S. ROGERS,

President,
American Shear Knife Company,
Homestead, Penna.

RICHARD C. SCHEY,

Field Engineer,
General Electric Co.,
Pittsburgh, Pa.

T. C. MAYBERRY,

Superintendent of Cold Strip Mill,
Great Lakes Steel Corp.,
Ecorse, Michigan.

WILLIAM J. REES,

Mechanical Engineer,
Great Lakes Steel Corp.,
Ecorse, Mich.

FRED I. STUART,

Chief Electrician,
Carnegie-Illinois Steel Corp,
Vandergrift, Penna.

L. T. GUESS,

Electrical Department,
Carnegie-Illinois Steel Corp.,
Irvin Works,
Dravosburg, Penna.

H. G. ROSS,

Sales Engineer,
Tool Steel Gear & Pinion Co.,
Cincinnati, Ohio.

JOSEPH ROUBICEK,

General Manager,
Associated Engineers,
Birmingham, Alabama.

HOMER A. SMITH,

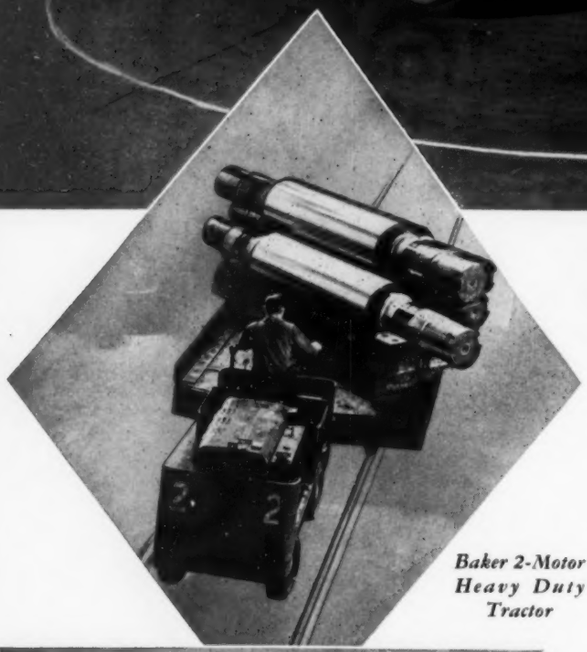
Engine Builders Department,
Socony-Vacuum Oil Company,
Pittsburgh, Penna.

J. T. SUDDUTH,

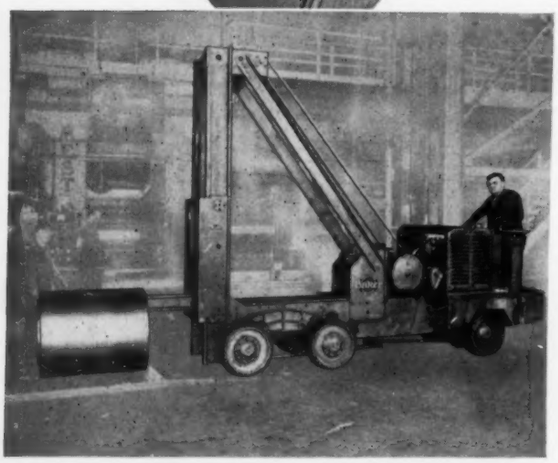
District Representative,
Tool Steel Gear & Pinion Co.,
Birmingham, Alabama.

LAWRENCE A. YOUNG,

Designer,
Rust Furnace Co.,
Pittsburgh, Pa.



Baker 2-Motor Heavy Duty Tractor



Baker 15,000 lb. Capacity 6-Wheel, 4-Wheel Drive Ram Tractor

CENTER CONTROL FORK & RAM TRACTOR

● Starting eighteen years ago, with the first ram tractor ever built for steel mill service, BAKER has steadily led the way in giving the industry stronger and more efficient equipment for the handling of coils and sheets. In the center-control types, shown above, BAKER sets a new high in maneuverability, free-vision operation, exceptional accessibility and easy maintenance. In these machines you get . . . option of either full contactor or drum controllers on travel, hoist and tilt . . . foot control in first speed (for "inching") . . . dynamic brake . . . wide-angle steer with short turning radius . . . and full protection for operator and all units. ●

Send today for Bulletin X-12 which gives the complete story of these new, outstanding Bakers. Capacities up to 25,000 lbs.

NOTE—*Watch this space next month . . . it will announce an outstanding new feature, developed exclusively by Baker for Baker Trucks, both new and old.*

Baker

BAKER INDUSTRIAL TRUCK DIVISION
of THE BAKER-RAULANG COMPANY
2166 West 25th Street • Cleveland, Ohio

The most economical way to handle material is NOT to HANDle it

DHS BRONZE

DUCTILITY · HARDNESS · STRENGTH

LONGER LIFE · LOWER COST

ENGINEERS FIND MANY APPLICATIONS FOR THIS UNUSUAL BRONZE

UNMATCHED PHYSICAL PROPERTIES

. . . Combined With Excellent Wearing Qualities!

DHS Grade No. 2

Ult. Ten. Str., psi.	115,000 min.
Yield Point, psi.	90,000 min.
Elastic Limit, psi.	55,000 min.
Elongation in 2", %	12 min.
Reduction of Area, %	12 min.
Brinnell Hardness No.	225 min.

For all applications where lineal contact speeds do not exceed 250 feet/minute.

This D H S #2 Bronze Worm Gear is 43½" O. D.; 7¾" face; 40" P. D.

BARTLETT HAYWARD DIVISION

Baltimore, Md.

ANOTHER ★ KOPPERS PRODUCT

★ Koppers' experience . . . as designer, builder, producer, manufacturer, operator and distributor . . . makes this company your best source of supply for hundreds of products.

Thirty-Third ANNUAL CONVENTION an IRON & STEEL EXPOSITIO

A. I. & S. E.

HOTEL STEVENS, CHICAGO, ILL. -- SEPT. 28, 29, 30 -- OCT. 1, 193

Herewith is presented a partial list of subjects to be discussed at the technical sessions:

1. The Possibilities of Producing Various Structural Shapes by the Cold Rolling of Strip Steel
2. The Manufacture and Use of Iron and Steel Rolls
3. Forged Rolls
4. Blast Furnace Design and Practice
5. Developments in Rolling Flat Steel Products—1937
6. Electrolytic Cleaning Lines for the Removal of Oil from Strip Steel
7. Corrosive Proof Tank Lining
8. Mordern Steam Power Developments
9. Factors Influencing the Selection of Insulated Cable for Steel Mills
10. D. C. Drives for Mill Run-Out Tables and Coilers
11. Load Factor on Low Voltage D.C. and A.C. Systems in Steel Plants
12. Steel Mill Lighting
13. Surges and Their Effect on Transformers
14. Organization and Functions of a Steel Plant Maintenance Dep
15. Testing Department of a Steel Plant
16. Reasons Covering the Use of E. P. Lubricants
17. Lubrication of Morgoil Bearings
18. Protective Atmosphere for Annealing Furnaces in Ste Mills—Their Types, Purification and Application to V rious Processes
19. Complete Control of Recuperative and Regenerati Soaking Pits
20. Generation of Waste Heat Steam from Gas Engine Exhau
21. Design and Operation of New Boiler House
22. Welding Economies and Application
23. The Development and Application of Covered Electrode A Welding
24. Alternating Current Welding Advance

View of Cold mill, Carnegie-Illinois Steel Corp., Gary, Ind., to be shown members and guests on Wednesday, September 29, 1937.

View of 76" mill, Inland Steel Company to be inspected by the Association, Friday morning, October 1, 1937.

ADVERTISING PAGES REMOVED

MECHANICAL DEVELOPMENTS of Modern Cold Rolled Strip Mills

By JOHN L. YOUNG, Manager Machinery Sales
United Engineering & Foundry Co.
PITTSBURGH, PA.

Presented before the Annual Spring Conference, A. I. & S. E., Buffalo, N. Y., April 28-29, 1937

▲ THE development of the 4-high mill by the United Engineering and Foundry Company has revolutionized the rolling of steel in strip form, both hot and cold.

This activity among the steel producers started after the installation of the 4-high mill at the Revere Copper & Brass Co., Rome, N. Y. This was the first commercial roller bearing 4-high mill.

Based upon that thought in mill design, the Columbia Steel Company at Butler, Pa., installed the 4-high hot and cold mills and at the same time, the Weirton Steel Company at Weirton, W. Va., installed their 4-high hot and cold mill. These were immediately followed by the Allegheny Steel Company, Brackenridge, Pa., the Trumbull Steel Company at Warren, Ohio and the American Rolling Mill Company at Middletown and Ashland, and the American Sheet & Tin Plate Company at Gary, Ind.

JOHN L. YOUNG

With each new installation, there were developments of a basic nature that helped promote the further advancement of the art, especially from a standpoint of the hot mill.

The cold mills at Butler were arranged as tandem or individual stands for strip rolling only, while at Ashland the tandem method for sheets only was established as was also true of the tandem mill of Allegheny Steel Company.

The tandem method primarily for strip was also set up at the Weirton Steel Co. for the cold product.

The Trumbull set-up was both the tandem and the individual stand arrangement similar in many respects to the Butler installation.

The Gary Tin Mill set-up was a hot mill only and the product was used almost entirely as breakdowns for the old process of tin plate manufacture.

Since that beginning, the successive mills, both hot and cold have been made wider and wider, bigger and bigger, faster and faster and more mechanically and electrically controlled until we now see the building of the largest mill of them all at the Corrigan-McKinney Division of Republic Steel Corp. in Cleveland, Ohio.

This mill will be 98″ wide to roll a normal maximum product width of 92″ and the top delivery speed of the hot mill will be 2120 F.P.M. or about 25 miles per hour delivery speed from the last finishing stand.

The cold mills will be of similar size with interchangeable housings, back-up rolls, bearings, screw-downs and all such parts as nearly as possible. This is an important point from the operating standpoint.

The hot mill consists of a conventional continuous ten stand mill with two scale breakers, making twelve stands in all. All 4-high stands and the broadside mill are equipped with Morgoil bearings on the back-up roll necks and also the 2-high scale breakers, both roughing and finishing are equipped with Morgoil bearings. The work rolls of the 4-high mills and the broadside mill are equipped with Timken tapered roller bearings.

All stands except the scale breakers are of the 4-high type and all are similar except the broadside mill and that mill is practically a duplicate of the broadside mill at the Gary Sheet Mill. The back-up roll diameters and bearings of the broadside stand, the other nine 4 high hot stands, and the five cold stands are the same and interchangeable. The work rolls and bearings of the cold mills are naturally smaller than the hot mill and are not interchangeable from that standpoint and the fact that forged steel rolls are used in most of the cold mill stands. I say most because some of the rolls will be of a new type cast roll, especially for the roughing stands of the tandem cold mill.

As our paper this evening is supposed to be centered on the cold mill part, let us briefly describe some of

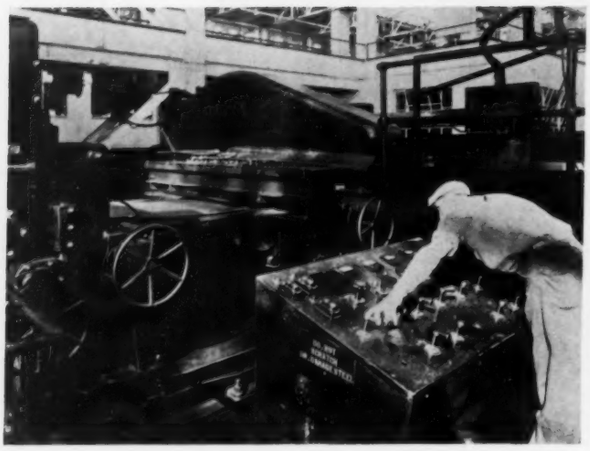


Figure 1—Strip welding line with shear in position to shear rear end of leading strip and front end of trailing strip.

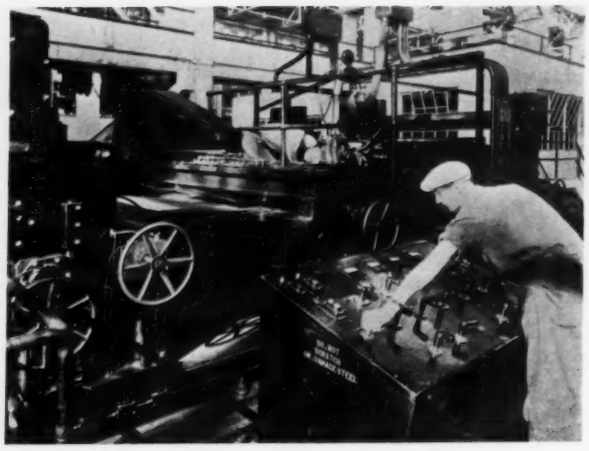


Figure 2—Strip welding line with shear retracted and with welding frame in position.

the major differences of this Corrigon-McKinney mill as compared to other mills built even recently or yet building. All of this tends again toward that further development that has been going on ever since the Rome mill was built and we are always trying to look ahead—toward the future that we can see, dream, visualize or estimate.

First, the welding of strip into longer coils is here. Just what form will be the answer is not to be stated at this moment. Will it be the butt, carbon arc, or gas method of welding? We must wait for a little further development to be sure.

All three types are now being used with various degrees of success. Whether the welder should be in the pickle line or elsewhere is yet to be settled and if the time element can be licked, it seems as if the pickle line is the logical place based upon the present arrangements of continuous pickling—more about that later.

The carbon arc welder at Ford (Illustrations 1 and 2) is the first of its type and with this installation a basic principle has been developed. This basic principle is the single clamping of the strip for shearing and welding and the retractible shear to allow this single clamping arrangement so that the ends of the strip remain in the position where they have been sheared for the welding process.

The time required and the space required for the above unit is too great for a pickle line based upon present experience. However, a similar shearing unit is now being installed at the Granite City Steel Company using the gas type of head and it is estimated that the time cycle will be considerably reduced by this method. The Granite City unit will not be in a pickle line of the continuous type, but will be used in the rewinding line ahead of the 4-high reversing cold mill (Illustration No. 3) as the most logical position for the mill arrangement at Granite City. By welding the coils together in the rewinding line, large diameter coils can be placed on the mandrels, which in turn are transported to the reversing cold mill for cold reduction. The reason for placing the welder in the rewinding line at Granite City is that the coils are pickled in the new United rotary type pickler that will be described later and the coil diameter is limited in the pickling application. Therefore, standard size coils as produced on their hot strip mill are more satisfactorily handled through the loose coiling and pickling operations up to the rewinding line just described.

Butt welders have been installed at the Inland Steel Company Company and at the Butler and Middletown plants of Armco. The Inland unit as far as we know is the only unit now operating in a pickle line, but we also understand the time element has not been so good and as a result, the continuous speed of the line is jeopardized. Additional units are now on order with a guaranteed betterment of this time cycle condition.

Whatever the final outcome of these various methods, we do know that production of cold mills can be increased materially with longer coils. We know of one case of a stand reversing cold mill that increased its production 15% by doubling the size of the coil. At Ford, production has been increased 30% by welding three coils together. At the Gary Sheet Mill of the Carnegie-Illinois Steel Corporation, coils have been welded together and wound on the mandrels for their reversing cold mills for several years and this has been done by hand with a gas flame.

With production increased, we are looking to the future at the Corrigan-McKinney Plant by designing all cold mill equipment to handle coils up to 700 pounds per inch of width. That equals a coil 30″ I.D. x 64″ O.D. If the full width of 92″ is utilized, the maximum coil weight will be around 65,000 pounds. We must agree that would be some coil and we may laugh now, but a few years from now it may be looked upon in an entirely different manner.

The basic design of the 4-high mills is similar to other recent installations.

There, of course, has been an open discussion of the relative merits of roller vs. flood oil bearings for back-up roll necks as well as the various types and makes of roller bearings and for me to say that the tendency seems to be leaning toward the oil bearing is not a matter of swallowing words made previously before the Association of Iron & Steel Engineers, but purely a matter of development. The oil bearing is doing a fine job and so is the roller bearing.

Here again a question arises as to the type of oil bearing. Personally, it looks and seems logical that the tapered neck and the bearing that can be removed as a unit seems to be the answer. There are numerous reasons that may be summarized as follows:

In roller bearings, we worked toward a design that would be self contained with the chock so that the unit would remain sealed when removed from the roll neck for interchange. This can be and is possible also in an oil bearing. This prevents loss of oil or grease and prevents ingress of dirt during interchange or storage.

The average roller or oil bearing straight neck diameter is 50 to 55% of the new roll body diameter whereas the tapered neck allows an increase of 70/75%. This applies generally to roller or flood oil bearings. This means greater neck strength and greater allowable bearing pressures.

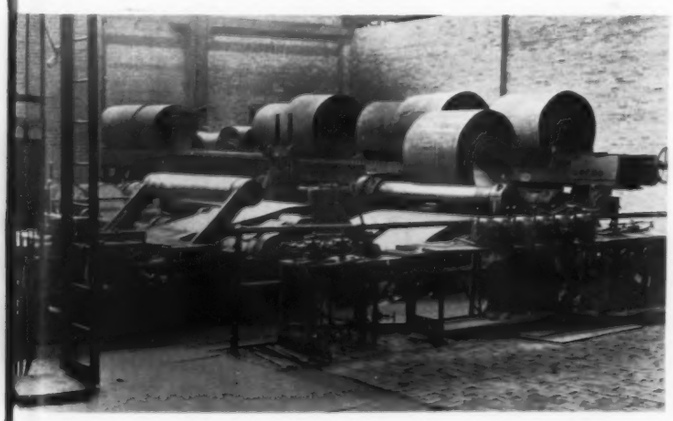
With the higher tendency toward higher speed, the tapered neck also allows a closer fit between the roll neck and the bearing sleeve to prevent scoring. Need I say more?

Another important point in favor of the oil bearing is the additional bearing capacity available for a given roll diameter, or the possibility of a greater turn-down of the roll with a smaller bearing which means longer roll life, or a combination of the two.

A mill of given dimensions can be built with roller bearings or oil bearings at approximately the same cost.

All original mill designs included sleeve bearings on the work roll necks. The first hot mill to be equipped with roller bearings on the work rolls was the Wheeling Steel Corporation mill at Steubenville. Since that time, all hot and cold mills have included roller bearings as standard equipment for that position and a number of mills have been changed over.

Figure 4—Feeder uncoiler showing coil conveyor, cradle rolls and pinch roll on entry side of tandem strip mill.



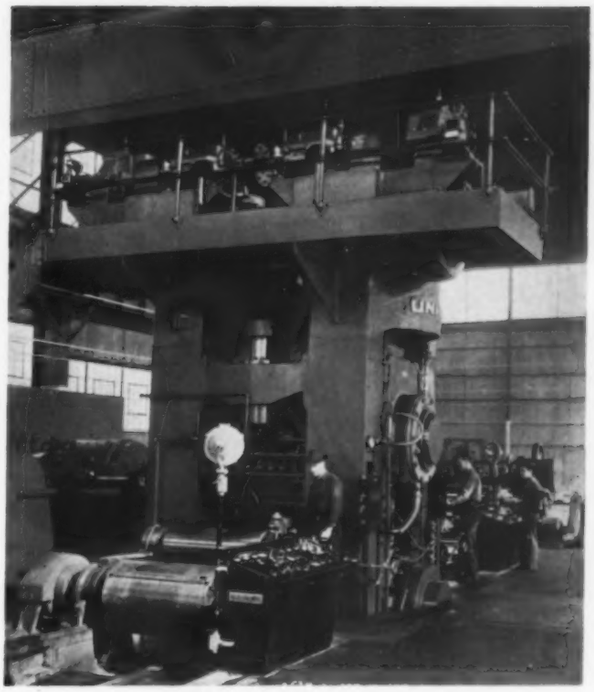


Figure 3 — 16½" & 49" x 42" 4-high reversing cold strip mill, Granite City Steel Company, Granite City, Ill.

The ability of the roller bearing to definitely align the work rolls in relation to the back-up rolls without successive bearing or chock adjustment during rolling has definitely increased production and allowed the higher speeds we now use in both hot and cold mills and also has cut down the time for roll change.

The use of the latch type chock clamping method, both in the windows for the back-up chocks and for the work roll chocks in the back-up chocks has again tended toward the cutting down of roll changing time and simplified the operation.

The use of the roller bearing in screwdowns, mill drives, pinion stands, miscellaneous gear drives, table rollers, and all other accessory equipment has become a standard during this process of development until now they are considered as much a part of the general design as the rolls or the housings.

Another interesting development at Corrigan-McKinney is the feeder and uncoiler for the three-stand tandem 98" cold mill, and this takes us back through the development of such a unit.

Reference to these larger welded coils was made previously. As these coils increase in width and diameter and corresponding weight, it becomes necessary to handle these coils mechanically ahead of the mill.

The first unit built of this type is at the Otis Steel Co. in connection with their 72" tandem cold mill. This is used to uncoil and feed the mill. (Illustrations 4 and 5.)

This unit at Otis consists of a gravity coil conveyor to bring the coils from the adjoining building where they have been pickled. One coil at a time is tilted off the conveyor onto the two cradle rolls where the coil is rotated until the outside end of the strip is in

Figure 5—Feeder uncoiler showing coil in uncoiling position and the following coil in position on the cradle rolls.

position to be held firmly by a magnet. As the last end of the preceding coil is leaving the cones, the cradle rolls are tilted, allowing the coil to roll out, but leaving the end held by the magnet. The coil unwinds as it goes down the slope and is lowered gradually by the finger into its position at the uncoiler where the cones are brought into their relative positions to pick up the coil. At this moment the magnet is released and the loose end through the spring in the steel flies over the uncoiler into position on the approach table where the upper swinging pinch roll is brought down into position and the strip is then fed into the mill.

The unit at Otis has been entirely successful and satisfactory, but it takes up quite a bit of floor space and is a costly unit to manufacture.

The next unit developed is at the Ford Motor Company and is used in connection with the 3-stand 56″ tandem cold mill. (Illustrations 6 and 7.)

This unit is similar in principle to the use of the magnet on a swinging arm, but the coil is brought into its position for uncoiling before the magnet takes hold of the outer end of the coil and delivers that end to the pinch rolls so that the strip can enter the mill. This unit has also been very successful.

The next unit was installed last year at the American Rolling Mill Company, Middletown in connection with their 3-stand 80″ tandem cold mill. (Illustrations 8 and 9.)

This unit was somewhat simplified and the magnet was eliminated.

Figure 6—Feeder uncoiler, end view, for 56″ 3-stand tandem cold strip mill at the Ford Motor Company.

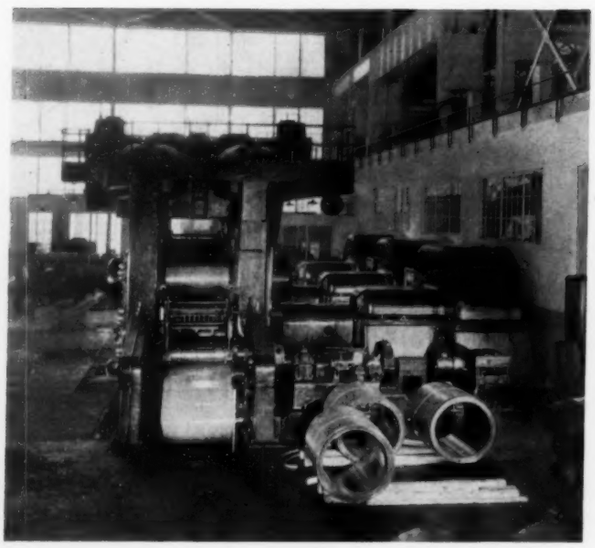
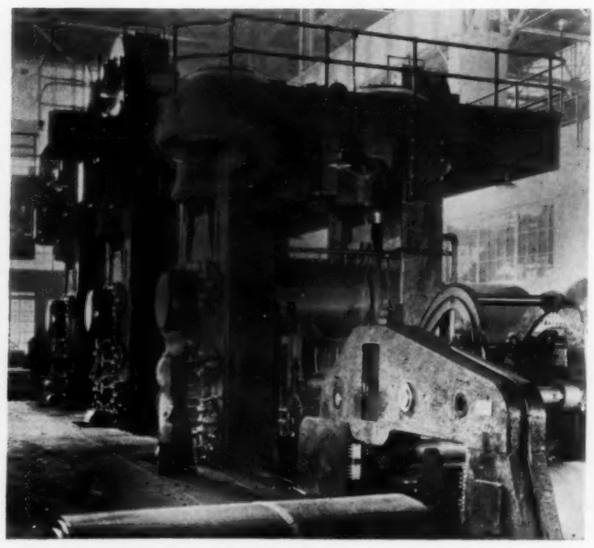


Figure 7—Feeder uncoiler, side view, for 56″ 3-stand tandem cold strip mill at the Ford Motor Company.



In designing the Corrigan-McKinney unit, it was found desirable to incorporate the good points of the Otis and Ford design and the simplicity and compactness of the Armco design.

The coil will be deposited on two cradle rolls similar in general arrangement to the Otis unit. The magnet will take hold of the outer end of the strip and bend the end over a block. The magnet will then be released and the coil rotated so that this opened end will be in sticking position to enter the pinch rolls of the feeder. This operation is being carried on while the preceding coil is being uncoiled in the cone type uncoiler.

As soon as the last end of the preceding coil leaves the uncoiler, the carriage upon which the cradle rolls are mounted moves forward actuated by an air cylinder so that the cradle rolls with the coil come into the position of the cone type uncoiler and at the same time the opened end of the strip is fed into the pinch rolls. This allows the front end of the trailing strip to follow immediately behind the back end of the preceding strip so that there will be no time delay between the two strips passing through the mill.

The coil will start to unwind on the cradle rolls as the cones are brought into position to pick up the coil. When the cones have taken position at each end of the coil, the cradle rolls will be lowered by a hydraulic elevator and when they are clear of the coil, will be retracted to their original position by the same air cylinder and while that coil is being unwound, the next coil is being prepared as was the preceding coil.

This unit should eliminate most of the man-handling that usually goes on ahead of one of these mills that are fed manually.

The unit in general is designed to do the various operations in similar motions and manner to the method of doing it by hand, but in this case the work will all be done mechanically.

A remark was made previously about the present system of continuous pickling. It seems fitting and proper that the latest development in pickling should be described briefly at this meeting because it all tends toward the answer in cold rolling and the unit has now been in production.

This system is entirely different, so different, that different and diverse opinions have been expressed only recently about the outcome of this experiment. Some have called it a noble experiment, but now the answer is available and that answer is "It works."

This unit has just been started, but the results so far are more than gratifying. It is estimated that one of these units can be installed complete, including buildings and foundations for between one-half and two-thirds the cost of a continuous pickler and that it will deliver at least equal tonnage of comparable size product.

This installation consists of a loose winder that prepares the coils as shown in Illustrations 10 and 11.

The loose coils are then taken to the charging position of the rotary pickler where a mandrel is inserted and the supporting chains are placed in position on the sprockets of the mandrel. (Illustrations 13 and 14.)

The mast with its four positions is then elevated hydraulically and rotated 90° so that the coil is directly over the pickle tank. The mast is then lowered so that the coil on its mandrel is completely submerged in the solution.

The mandrel is then rotated slowly by an electric motor on the outer end of the mast arm, which in turn drives the chains through sprockets. As the coil rotates, the loose wraps are at the bottom of the coil

Figure 8—Feeder uncoiler, end view, for the 3-stand 80″ cold strip mill, American Rolling Mill Company, Middletown, Ohio.

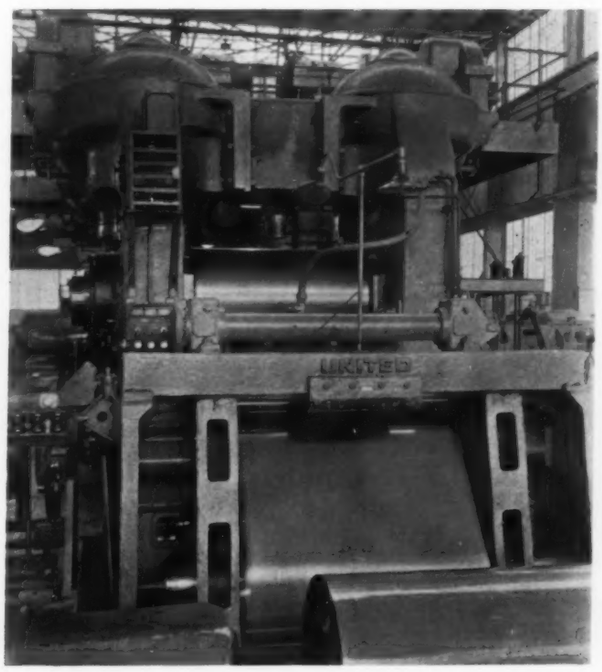


Figure 9—Feeder uncoiler, side view, for the 3-stand 80″ cold strip mill, American Rolling Mill Company, Middletown, Ohio.

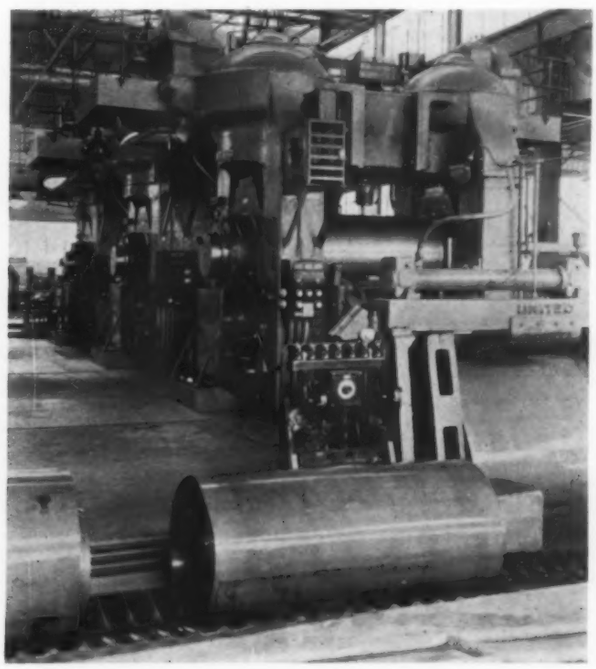


Figure 10—Loose coil as it comes from the loose coiler.

and the acid is circulated by a motor driven impeller from the top of the tank down through the tunnel and through the loose wraps of the coil. This positive agitation and circulation of the acid tends to increase the effectiveness of the pickling solution and in that way speed up the operation or cut down the pickling time.

Approximately four to eight minutes is required for this cycle and after the strip has been pickled properly, the mast is again elevated and rotated 90° and the coil is dropped into the cold water tank where a similar circulating system is used to accelerate the cleaning.

The next operation after the mast has again been elevated and turned 90° is the oiling tank where again the soluble oil solution is circulated in a similar manner to the method used in the acid tank and the cold water tank.

Figure 11—Loose coil ready for placing in position for entering the mandrel.

The next position is the discharge position where the chains are removed from the mandrel sprockets and the mandrel removed. The coil is then rolled out of position and another coil takes its position for the charging operation.

This means that as one coil is being discharged and the other charged in the same position, there are three other coils on the three other mandrels going through the cycle of operation as described above.

The mandrels at Granite City are designed for 90″ maximum width material, which means that for narrower material, more than one coil can be mounted on each mandrel in order to speed up production.

May we look forward once more to an interesting development especially for hot strip mills. All credit for this idea must go to Mr. Howard C. Goodrich of the Carnegie-Illinois Steel Corp. at McDonald. Mr. Goodrich developed and patented this device for setting the 43″ hot strip mill rolls and adjusting the corresponding motor speeds. He describes the unit as follows: (Illustration 12.)

There are three types of adjustment that can be made on the board. All other characteristics of the individual mill are built into the board which must be made to order for each mill.

1. Adjustment for Roll Size:

This is done by turning the knob "A" about a quarter turn to the left to unclamp it; then, using the knob as a handle, moving the upper slide up or down until the correct roll size appears opposite the index in the window "B". The knob is then turned to the right to reclamp the slide.

This adjustment needs to be made only when rolls are changed in the mill; it need not be touched when changing to a different finished thickness of strip.

The same slide that carries the roll size adjustment also has fastened to it the motor speed scale, since a difference in roll size is compensated for by a proportional difference in speed.

2. Adjustment for Roll Opening, Percent Reduction, or Motor Speeds:

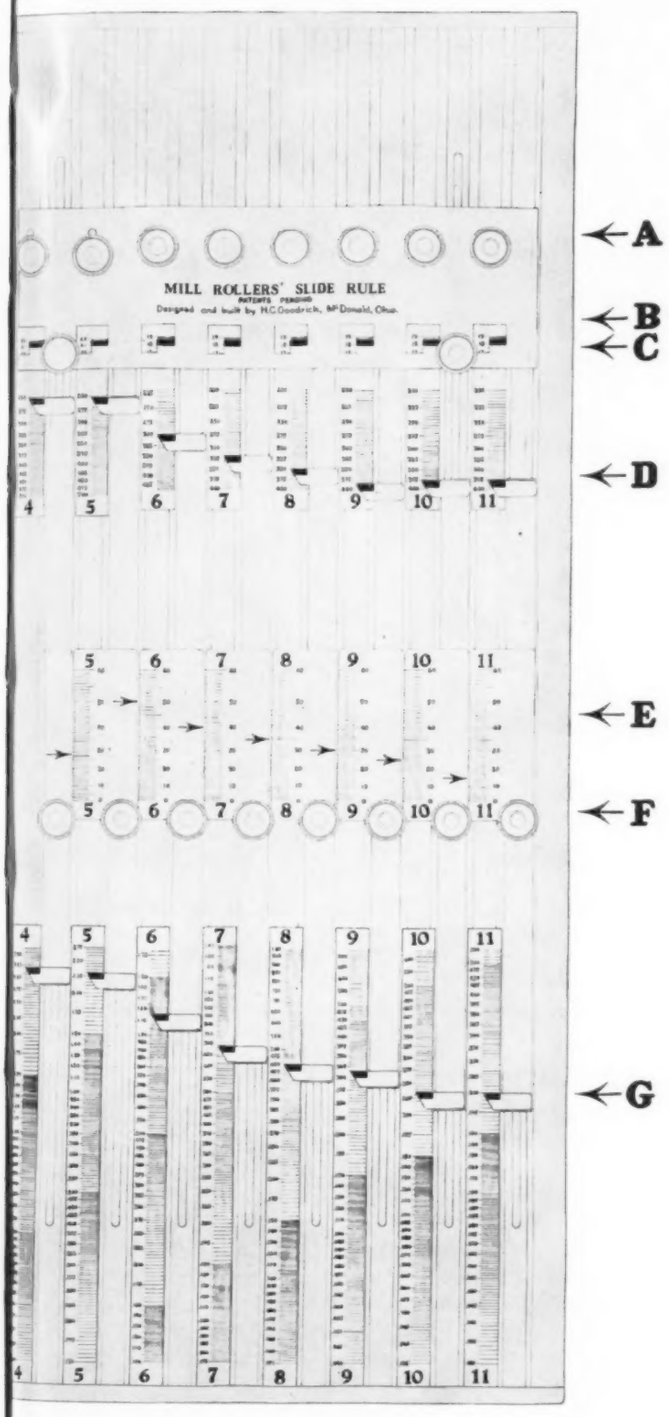
These slides each carry three indexes; one (G) at the bottom pointing to the roll opening scale, another (E) on the percent reduction scale, pointing to the next adjoining percent reduction scale, and one more (D) at the top, pointing to the motor speed scale. The slide is unclamped, moved and reclamped by the knob "F", and may be set up to whichever of the three sets of indices that the occasion demands. This will be discussed later.

3. Adjustment for Finishing Speed:

This adjustment is made by moving the bridge which carries with it all of the motor speed scales. Both knobs "C" are loosened and used as handles to move the bridge. You are limited in your selection of finishing speed by the upper and lower limits of each indi-

vidual stand. It sometimes occurs on certain setups that a variation of only 20 or 30 R.P.M. on the last stand will move you from the top limit on some one stand to the bottom limit on some other stand. At other times a setup may throw you entirely out of your available speed range; that is, you may be over the top limit on one or more stands and at the same time below the bottom limit on others. The board will indicate what changes must be made in the setup to correct this trouble.

Figure 12—Goodrich slide rule.



FUNCTIONS OF BOARD

The board has a number of useful functions, the most important being:

1. To predetermine the correct roll opening and motor speeds for any other within the range of the mill.

Method: (*a*) Correct roll sizes are set up at "B."

(*b*) The lower slide on the last finishing stand is set and clamped so that pointer "G" indicates the desired thickness of the finished material.

(*c*) The next to the last slide is set up so that the arrow on percent deduction scale "E" indicates the percent reduction desired on the last stand. The percent reduction for each stand is characteristic for each individual rolling mill and does not vary greatly from order to order. It is calculated, or determined from experience and built into the mill. It is limited by the speed range and available horsepower of each stand; when perfectly calculated, it will cause each main drive motor to be loaded to the same percent of capacity and will also cause the speed of each motor to be in the same relative position in the available speed range.

The board is so constructed that when these characteristic percentages of reductions are set up for each stand, the scales "E" will be in a straight line across the board. It is realized, however, that conditions often arise when variation of even 10 or 20 percent from the characteristic reductions must be used. These variations must be left up to the judgment of the speed operator, roller, turn foreman, or whoever is responsible for setting up the board.

(*d*) All other lower slides are set up consecutively in the same manner and clamped in position.

(*e*) The bridge is moved so that the desired finishing speed is indicated.

(*f*) All indicated roll openings are marked down and sent to roller; all motor speeds are given to the speed operator.

2. To determine the actual roll opening at each stand in order to recalibrate roll opening indicators on the stands:

Method: (*a*) The mill must be running smoothly.

(*b*) Set up finishing stand slide at actual finished size as measured by the gauger.

(*c*) Move bridge so that actual motor speed is shown for the finishing stand. Get this speed from tachometer.

(*d*) Set all other slides to actual motor speeds as shown on the tachometer,

(*e*) Read correct roll opening at "G".

3. To determine the actual percentage of reduction occurring in each stand:

Method: (*a*) Set up the same as described above.

(*b*) Read percentages of reduction on scales "E".

4. To balance up a mill when some motors are taking excessive loads:

Method: (*a*) Set board to actual rolling conditions at times of trouble.

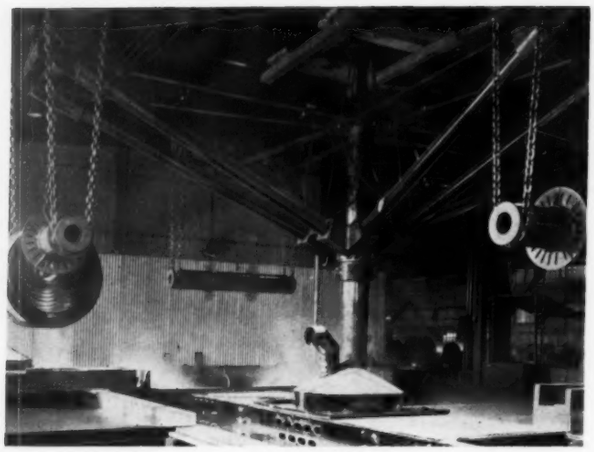


Figure 13—Rotary pickler with loose coil suspended on mandrel over the pickling tank.

(*b*) Adjust slides to permit lighter reductions on stands where motors are overloaded.

(*c*) Read new roll openings and motor speeds and make the necessary corrections to the mill. This method takes the guess-work and "feeling your way" out of such an operation.

5. To determine whether or not a given order can be rolled on the mill from a given size slab:

Method: (*a*) Set up the board as the order were to be rolled.

(*b*) See if the motor speeds fall within available ranges and if characteristic reductions are being made. A little experience will show what variations in percent of reductions are possible. A set to be "Dummied" on the mill is taken care of on the board by setting the reduction scale for that stand at zero."

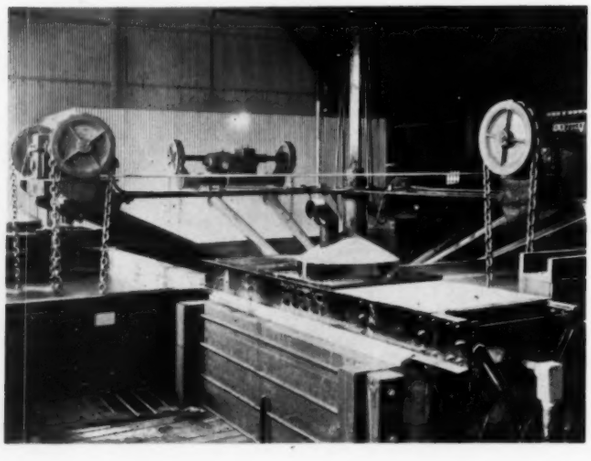
Following this paper, we will show movies of the new 4-stand tandem cold reduction tin plate mill recently installed by the Republic Steel Corporation of Niles, Ohio. (Illustration No. 15.) The mill size is 18″ and 49″ x 42″ and is equipped with roller bearings throughout the roll necks, screwdowns, drives, pinion stands and all accessory equipment.

One interesting item about this mill is that the first coil was produced as a complete coil of salable product on February 4th, 1937 exactly four months after the first shovelful of dirt was turned for the start of construction.

This layout comprises a continuous pickling line, the 4-stand tandem cold reduction mill and belt wrapper, two cleaning and shearing lines, annealing department, a plain bearing 2-high temper mill group of nine stands arranged as 3-stand tandem mills and the necessary tinning, sorting and shipping equipment.

It is the most modern layout in the tin industry today with no back tracking at any point of the product from the time the hot rolled coils are delivered to the storage bay. A complete flow-line of material is arranged by the well thought out layout.

Figure 14—Rotary coiler with mast lowered into pickling position.



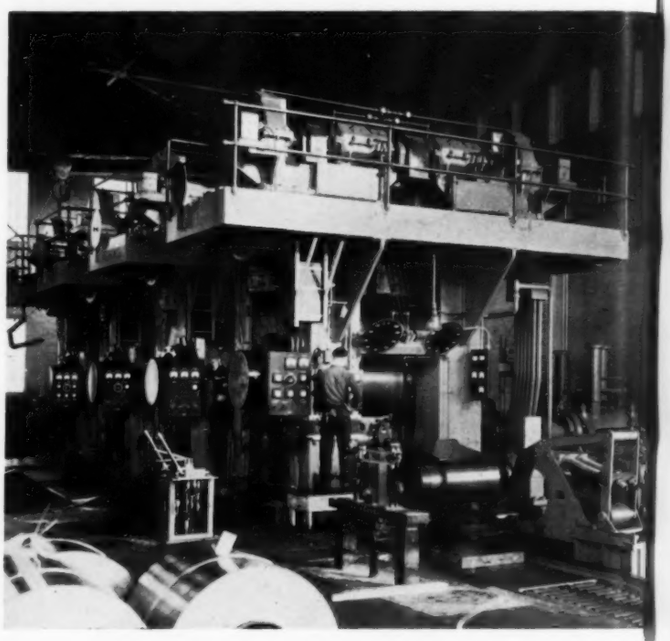


Figure 15—16″ & 49″ x 42″ 4-stand tandem tin plate mill, Republic Steel Corporation, Niles, Ohio.

The 4-high tandem cold mill is preceded by a simple coil box as shown in the movies and followed by the belt wrapper. It will also thoroughly illustrate and describe the operation of that novel development.

Another mill of this type consisting of four stands and operating at a top speed of 1350 F.P.M. and an average operating speed of 1225. F.PM., which also is the same speed of the Niles mill, during one of the recent months produced 16,414 tons of finished product averaging 27″/28″ wide and averaging .010″ thick. This mill is equipped with one of the standard United belt wrappers on the tension reel.

So much for details of the cold mills, but all of these details along with the developments outlined by Mr. Kenyon tend toward one answer—removing the mystery from the art of rolling steel. As we develop, we progress toward more complete mechanical designs that make the art of rolling more practical and simple and incidentally cut our costs and make a better product.

ELECTRICAL OPERATION of Cold Strip Mills

By A. F. KENYON, Steel Mill Engineer
Westinghouse Electric & Manufacturing Co.
EAST PITTSBURGH, PA.

Presented before the Annual Spring Conference, A. I. & S. E., Buffalo, N. Y., April 28-29, 1937

▲ THE cold rolling of steel strip to impart accurate gauge and highly finished surface, ranks among the oldest of rolling mill processes, yet the last few years has seen more continuous development and improvement in cold rolling equipment and processes than in almost any other department of the steel plant. For instance, ten years ago, the maximum width which could be rolled was about 30 to 36 inches; rolling speeds seldom exceeded 250 feet per minute; 100 to 125 pounds per inch of width represented the longest strip which could be produced on the hot mill; the largest mills utilized driving motors of only 500 HP. per roll stand, and 100 HP. on the tension reel. Today, a 93 inch wide mill is in operation, and a 98 inch mill is under construction, enabling the rolling of strip nearly eight feet wide; several 42 inch wide mills rolling light gauge strip for tinplate normally operate above 1200 feet per minute, while the larger mills producing sheet gauge material run at 500 feet per minute or faster; coils weighing 300 pounds per inch of width are commonplace and some new cold strip mills are capable of handling coils of twice this size; even narrow tinplate mills require motors of 1000 to 1500 HP. per stand, and there is now operating in the Chicago area a single stand reversible type mill with a 4000 HP. mill motor and two 1500 HP. reel motors.

A. F. KENYON

These increases in rolling speed and width and length of strip rolled, with corresponding increases in the capacity and complexity of the electrical driving equipment, are notable in themselves, but have been achieved along with a very great improvement in the quality of strip produced. The first cold reduction tinplate mill was installed only 8 or 9 years ago, yet the cold reduced tinplate has proven to have so many desirable characteristics that the demand for it has increased enormously, thus necessitating the construction of many new cold reduction mills to replace or supplement existing hot tin mills. The annual cold reduced tinplate capacity at the end of 1936 was about 1,333,450 net tons, or about one-third of the total tinplate capacity, and new cold mills now under construction will increase the capacity to about 2,000,000 net tons, or to more than one-half of the total tinplate capacity. The growth in production of cold reduced sheet material has been no less remarkable, although extending over a somewhat longer time.

The subject of electrical equipment for cold rolling mills is much too broad to be considered in detail in the limited time available, however I will endeavor to touch on some of the different problems which have come up, describe the electrical equipment which has been installed to drive various cold rolling mills, and list the operating results which are being obtained in different plants.

The single stand reversible cold reduction strip mill is a comparatively recent development, the first installations having been made at Gary in 1933, for the production of light gauge strip for tinplate. However, a number of arrangements which were developed for reversible type mills have since been adapted and used on tandem and other types of mills, so that a brief discussion of reversible mill operation seems appropriate.

A typical reversible cold reduction mill consists of a single four-high roll stand, and two tension reels located one on each side of the mill stand. The mill and reel drives are reversible, so that the strip may be unwound from one reel, passed between the reducing rolls, and

rewound on the second reel;—the mill rolls are then screwed down, and the operation reversed, so that the strip is unwound from the second reel, passed back through the mill, and rewound on the first reel; this reversible process being continued for as many passes as are necessary to effect the desired total reduction. The reel motors are controlled so that they operate alternatively as motor or generator, such that the machine connected to the winding reel on the delivery side of the mill functions as a motor to supply a portion of the rolling power through the tension exerted on the strip and wind the strip into tight coils; and such that the machine connected to the unwinding reel on the entry side of the mill functions as a regenerative braking generator, driven by the pull of the strip entering the mill, to exert a back tension on the strip. The back tension on the strip entering the mill, and the forward tension on the strip leaving the mill, are independently adjustable and under the roller's control, providing great flexibility, and making this type of mill adaptable to varying operating conditions.

The Westinghouse Company have furnished the principal electrical equipment for some thirteen reversible type cold reduction mills, as listed in Table I. Items 1 and 2 represent two very small mills used to roll high carbon and alloy steel strip such as required for razor blades, etc. Items 3 to 10 are medium size mills used primarily to produce light gauge strip for tinplate. Items 11 to 13 are extremely large heavy mills capable of producing wide sheet gauge strip such as required for automobile bodies. It is to be noted that the earlier mills were geared for relatively low maximum rolling speeds, while the more recent installations, such as the 42″ mill, item 8, and the 72″ mill, item 11, are geared for much higher rolling speeds, made possible by improved operating practice and the longer coils which are now available.

Various methods of handling the strip on the entry side during the first pass are in use in different plants. At some mills the strip is merely drawn from a coil box, and no attempt is made to exert any back tension on the strip. However most mills have found that back tension is desirable during the first pass as well as during the later passes, in order to better guide the strip into the mill, permit making heavier reductions, enable operating at higher speeds, etc. In one plant early practice was to wind the strip on a reel drum preparatory to the rolling, thus enabling the same mill operation as on

TABLE I

Installations of Single Stand Reversible Cold Reduction Strip Mills

No.	Company	Location	Size of Mill	Date Installed	Maximum Rolling Speed	Motor HP.	
						Mill	Each Reel
1	American Steel & Wire Company	Worcester, Mass.	7½″	July, 1935	1000	125	25
2	American Steel & Wire Company	Worcester, Mass.	7½″	July, 1935	1000	125	25
3	Pittsburgh Crucible Steel Company	Midland, Pa.	26″	Oct., 1936	800	800	250
4	Inland Steel Company	Indiana Harbor, Indiana	38″	1935	950	750	300
5	Carnegie-Illinois Steel Corporation	Gary, Indiana	42″	June, 1933	800	1200	500
6	Carnegie-Illinois Steel Corporation	Gary, Indiana	42″	Nov., 1933	800	1200	500
7	Youngstown Sheet & Tube Company	Indiana Harbor, Indiana	42″	Feb., 1934	1125	2000	600
8	Youngstown Sheet & Tube Company	Indiana Harbor, Indiana	42″	Jan., 1937	1350	1750	500
9	Republic Steel Corporation	Warren, Ohio	42″	Nov., 1935	1000	1200	300
10	Dominion Foundries & Steel, Ltd.	Hamilton, Ontario	42″	March, 1937	1125	1500	600
11	Carnegie-Illinois Steel Corporation	Gary, Indiana	72″	Oct., 1936	740	4000	1500
12	Carnegie-Illinois Steel Corporation	Gary, Indiana	84″	Feb., 1934	500	1500	700
13	Ford Motor Company	Detroit, Michigan	84″	1935	600	2000	800

Figure 1—42″ Single Stand Reversible Type Cold Reduction Strip Mill. Back tension on the Strip during the First Pass is Obtained by Pulling the Strip Through the Leveller shown in the Right Foreground.

the later passes. This, however, entailed considerable expense due to the investment in the large number of reel drums and the additional winding operation, and in this plant two 42 inch reversable mills have recently been altered by the installation of a double cone type feed reel on the entry side of the mill, from which to pay out the strip during the first pass. This cone type feed reel is equipped with a 100 KW. regenerative braking drag generator, and during the first pass this drag generator is connected into the main circuits in the place of the normal reel motor, thus enabling the same control of back tension as during the later passes.

At another plant, each of the two 42-inch mills has a roller leveller installed on the entry side. The leveller is motor driven to inch the end of the strip up to the mill, but during the rolling of the first pass the leveller motor is disconnected, and the back tension is obtained by pulling the strip through the leveller rolls. Figure 1 is a general view of the No. 1 mill, put into service early in 1934, and shows the leveller in the right foreground. Figure 2 is a similar view of the No. 2 mill, put into service in January of this year, and shows the general improvement in the design and arrangement of the mill equipment. Note that on both mills, the operator's master control benchboards are located a considerable distance back from the mill and reels, thus to some extent protecting the control equipment from the oil and water vapor, while still affording a clear view of all mill operations.

The reversible mill shown in Figure 2 is driven by a 1750 HP., 400/600 RPM., 600 volt, direct current reversible mill motor, and two 500 HP., 250/875 RPM., 600 volt, reel motors. Power for the operation of the mill and reel motors is supplied by a four-unit synchronous motor generator set, consisting of an 11,000 volt, 60 cycle, synchronous driving motor, 2000 KW., 600

Figure 2—42″ Single Stand Reversible Mill of Modern Design.

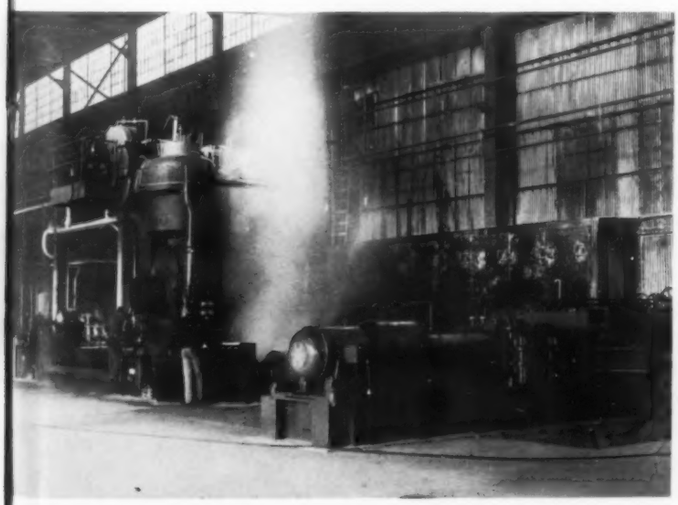


Figure 3—1750 HP. Mill Motor and 2250 KW. Main Motor Generator Set, Driving the 42″ Single Stand Reversible Mill shown in Figure 2.

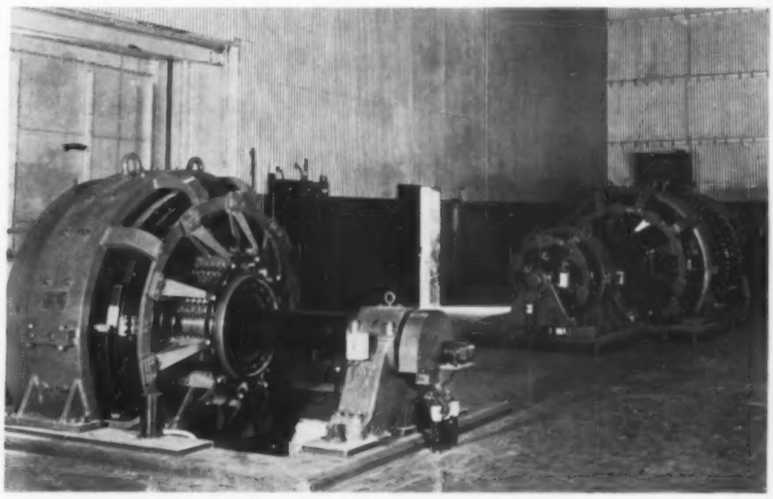


Figure 4—Variable Voltage Control Board for a 42″ Single Stand Reversible Cold Reduction Strip Mill.

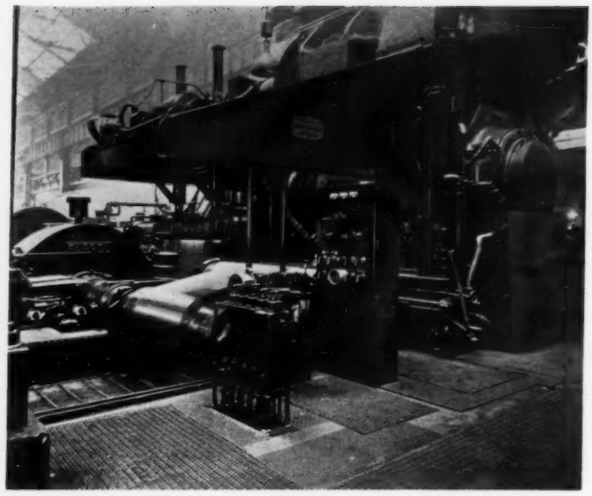


Figure 5—72″ Wide Single Stand Reversible Cold Reduction Strip Mill.

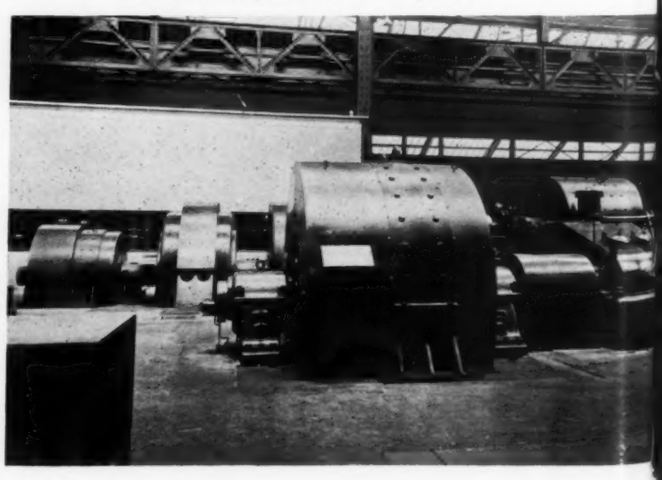
volt, main generator, 200 KW., 300 volt, unwinding reel booster generator, and 50 KW., 250 volt, exciter generator. The 1750 HP. mill motor and main motor generator set are shown in Figure 3. In this particular installation there is no crane in the motor room, so that the 1750 HP. mill motor, and 2000 KW. main generator and 3000 HP. synchronous motor of the motor generator set, were made with extended base and shaft to permit shifting the machine stators for inspection or repair.

Figure 4 shows the main control panelboard for the No. 2 reversible mill. The generator circuit breakers are located in the basement, and are not shown in this view. The group of three panels at the left control the main armature circuits of the 1750 HP. mill motor, and two 500 HP. reel motors. The six panels at the left of the long panelboard include contactors to select field and control circuits for either direction of operation, vibrating regulators to control the reel motor currents to maintain constant entry and delivery tension, and graphic meters to record mill and reel motor amperes, mill motor speed, and bus voltage. The remaining panels provide control for the exciter, synchronous motor, and various auxiliaries.

Figure 5 is a view of the entry side of a 72″ wide single stand reversible cold reduction strip mill, recently put into service and for rolling wide sheet gauge material at speeds up to 740 FPM. maximum. This mill has the distinction of employing larger individual mill and reel motors, and greater total motor capacity than any other cold roll mill now in operation. The mill rolls are driven by a 4000 HP., 150/300 RPM., 600 volt, direct current motor, and the reels by two 1500 HP., 150/525 RPM. motors. In Figure 6, the 4000 HP. mill motor is seen in the foreground, and one of the 1500 HP. special low inertia reel motors is shown in the right background. This mill is intended to operate with very high back tension to enable making very heavy reductions, and the equipment is arranged to permit operating with strip back tension up to about 200,000 pounds, and forward winding tensions somewhat lower. In Figure 5, note that the master control switches, adjusting rheostats, and indicating meters, are mounted on vertical control cabinets. Some operators feel that this arrangement of the master control is preferable to a control benchboard, as it brings the operator closer to the mill, and permits his closer observation of the rolling process.

Several schemes of main circuit connections have been employed for the control of the mill and reel motors. Figure 7, reproduced from the writer's paper presented before the 1933 Pittsburgh Convention and published in the March 1934 "Iron and Steel Engineer", shows schematically the principal armature and field circuit connections for an arrangement which has been used successfully for several reversible mills. It is readily understood that if the strip thickness is reduced as much as 50 percent by a single pass, the speed of the strip entering the mill will be only 100 minus 50 percent of the speed leaving the mill, and hence the unwinding reel on the entry side may have to operate

Figure 6—4000 HP. Mill Motor, and One of the 1500 HP. Reel Motors, Driving the 72″ Wide Single Stand Reversible Cold Reduction Strip Mill, shown in Figure 5.



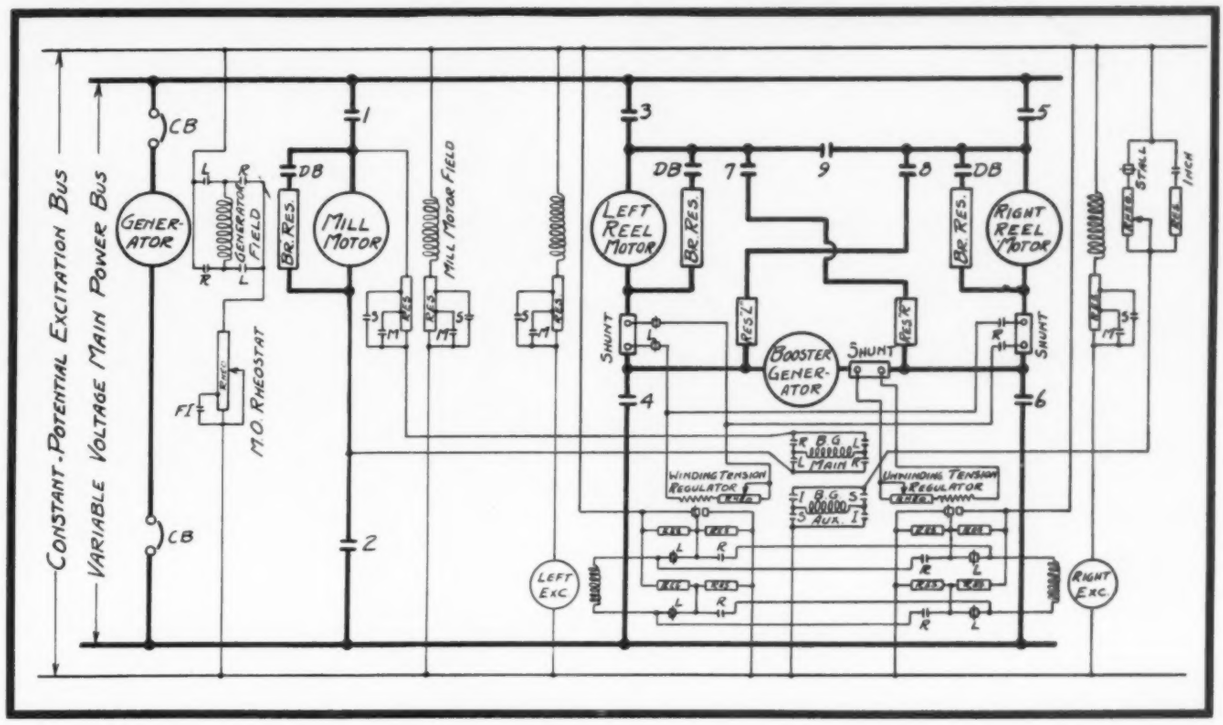
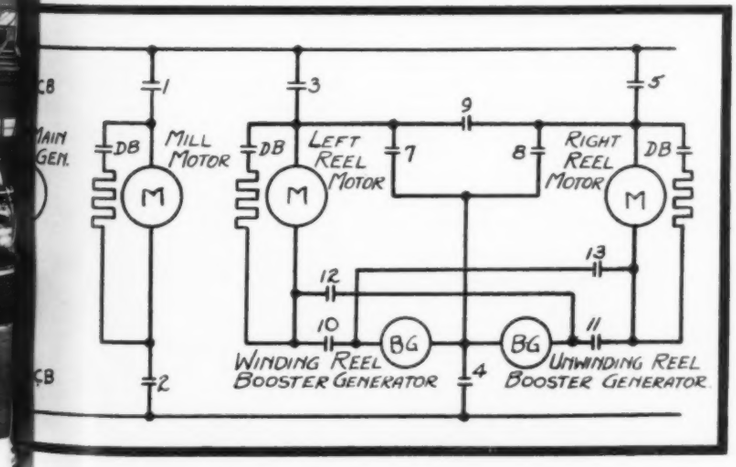


Figure 7—Connections for Single Stand Reversible Cold Roll Strip Mill with Two Reels.

down to 50 percent of the speed of the winding reel on the delivery side. In the usual layout the speed range of the reel motors by shunt field control is made sufficient only to take care of the range of speed necessary for the winding reel to accommodate the combination of mill working roll diameter, mill motor speed range, and range of coil build-up on the reel. There is therefore provided a booster generator which may be connected in series with that reel motor which is operating as the entry reel braking generator, thus requiring the braking generator to develop only comparatively low voltage when operating at the low speeds occasioned by the mill reduction. It will be noted that the booster generator receives its principal excitation from the main bus and hence its voltage output, and also the entry reel braking generator voltage output, vary in proportion to the mill motor and winding reel motor voltage.

Figure 8—Single Stand Reversible Cold Strip Mill Electrical Drive Main Connections Using Two Reel Booster Generators.



The reel motors must be built for wide speed range by shunt field control, and hence for comparatively low full field speed, with resultant high armature resistance as compared to the mill motor. The shunts required to actuate the tension regulators introduce additional resistance into the reel motor circuits. As a result it was found that when starting at low threading voltage, the reel motors were sluggish in starting, and could not be made to circulate the desired current. Thus full tension could not be obtained when running at low speeds, with conseqent "thick ends" on the strip. This difficulty has been overcome, insofar as the entry reel is concerned, by arranging the control so that immediately upon starting, the booster generator auxiliary field excitation is increased so as to increase the booster generator voltage and circulate full running current through the entry reel braking generator.

On an equipment just put into service at the Dominion Foundries and Steel, Ltd., the total required winding reel motor speed range was greater than could be obtained with shunt field control. To secure the necessary additional speed range there is provided a second booster generator, arranged to be connected in series with the winding reel motor, and thus enable the operation of the winding reel motor at voltages higher than the main bus voltage. The control is arranged to "jump" the auxiliary field excitation of both the winding reel booster generator and the unwinding reel booster generator immediately upon starting the mill, thus securing full entry and delivery tension at

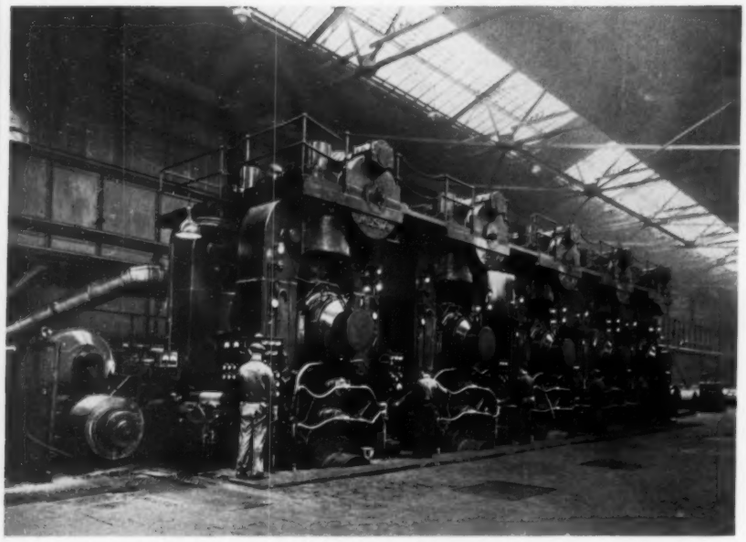


Figure 9 — 42″ Wide Five-Stand Tandem Cold Reduction Strip Mill.

once, and more quickly establishing normal rolling conditions. Figure 8 shows the armature circuit connections for the scheme using both winding reel and unwinding reel booster generators.

TANDEM COLD REDUCTION MILLS

The recent developments in tandem cold reduction strip mills have been principally toward the operation of all sizes of mills at higher speeds, increase in the size of mills to enable rolling wider strip, improvement in the reels and handling equipment to permit handling longer and heavier coils, and general refinement in the design of the mechanical and electrical equipment to more accurately control the rolling operation and improve the quality and uniformity of the product.

Within the last year and a half there have been installed a number of four-stand and five-stand 42″ wide tandem mills, for the production of light gauge strip for tinning, and geared for maximum final delivery speeds of 1200 to 1350 FPM. Experience with these mills has indicated that under favorable conditions even higher rolling speeds may be attained, and the output thereby increased. Two mills are now under construction, geared for a maximum rated delivery speed of about 1500 FPM., and speeds up to 2000 FPM are being considered for new mills.

Two four-stand mills now in operation, and geared for about 1350 FPM. delivery speed, each have a 400 or 500 HP. motor driving Stand No. 1, 1000 HP. motor on Stand No. 2, 1000 HP. motor on Stand No. 3, 1500 HP. motor on Stand No. 4, and 200 or 250 HP. motor on the tension winding reel, totalling about 4100 to 4250 HP. Each mill utilizes a 3500 KW. motor generator set for variable voltage power supply. Two five-stand mills each have a 500 HP. motor driving Stand No. 1, four 1250 HP. motors driving Stands No. 2, No. 3, No. 4 and No. 5, and a 250 HP. motor driving the tension winding reel, totalling 5750 HP. and utilizing a 5000 KW. motor generator set. Power studies indicate that a five-stand mill and reel, geared for a final delivery speed of 2000 FPM. will require total motor capacity of about 6500 HP. and power supply motor generator set of about 5000 KW.

One of the most recently completed 42″ wide five-stand tandem cold reduction strip mills is shown in Figure 9. This mill was geared for a rated maximum delivery speed of 1200 FPM. However it has been found that successful operation can be obtained and the output increased by operating at higher speeds, and changes have been made to permit operation up to 1500 FPM. and the mill normally rolls at about 1350 FPM. Figure 10 is a general view of the motor room. In the foreground is the 500 HP., 400/800 RPM., 600 volt, motor driving Stand No. 1, followed by the four 1250 HP., 300/600 RPM. motors driving Stands No. 2, No. 3, No. 4 and No. 5, and the 5175 KW. main motor generator set. The 250 HP. 250/1000 RPM., 600 volt, bracket type, reel motor is mounted

Figure 10—42″ Tandem Cold Reduction Strip Mill Motor Room.

on top of the reel gear unit, as shown in Figure 9. Figure 11 shows the factory assembled main variable voltage magnetic control board.

In the field of wide strip rolling there have been equally important developments. Until 1936, the widest tandem cold strip mill was 75″, enabling the rolling of strip not more than about 72″ wide. During the past year there were completed and put into service an 80″ mill at the American Rolling Mill Company, an 84″ mill at the Gary plant of the Carnegie-Illinois Steel Corporation, and a 93″ mill at the Great Lakes Steel Corporation, and during the present year there will be completed a 98″ mill at the Republic Steel Corporation. The 84″ mill at Gary is geared for a maximum rolling speed of about 550 FPM., and the 80″ mill at Middletown and the 93″ mill at Ecorse are both geared for maximum rolling speed of about

600 FPM. The new 98″ mill under construction at Cleveland will not only be wider than any previous cold reduction mill, but will be geared for a higher maximum rolling speed of 800 FPM., and will also have greater total capacity in driving motors than any other similar mill. Stand No. 1 will be driven by a 1500 HP., 300/600 RPM., 600 volt D.C. motor, Stands No. 2 and No. 3 by two 2500 HP., 225/450 RPM. motors, and the tension winding reel by a 600 HP., 250/875 RPM., 600 volt D.C. motor, making a total of 7100 HP. Even this motor capacity will probably not be enough to enable rolling the maximum width strip at the top speed, and it is expected that the wider material will be rolled at the base speed of 400 FPM., or slightly faster, and that the maximum speed will be used only when rolling about 60″ or narrower. Tentative plans for a proposed new 84″ three-stand tandem mill call for mill and reel motors totalling 9300 HP., to be operated from a 7000 KW. motor generator set.

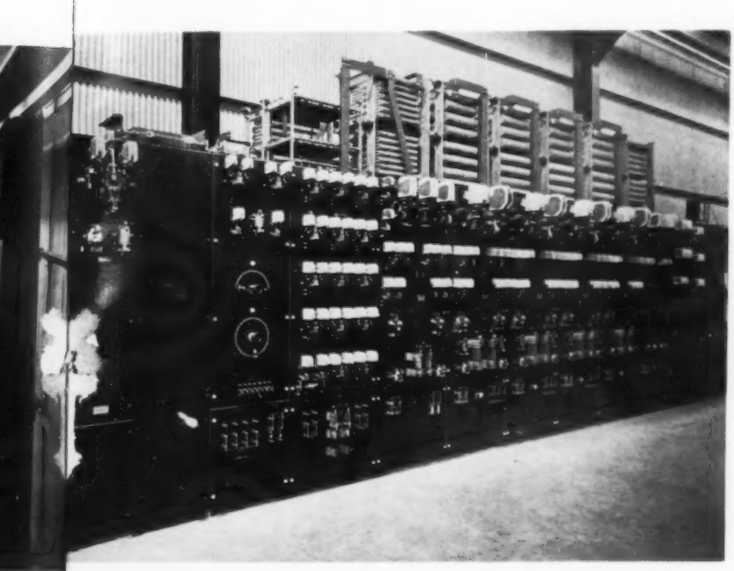


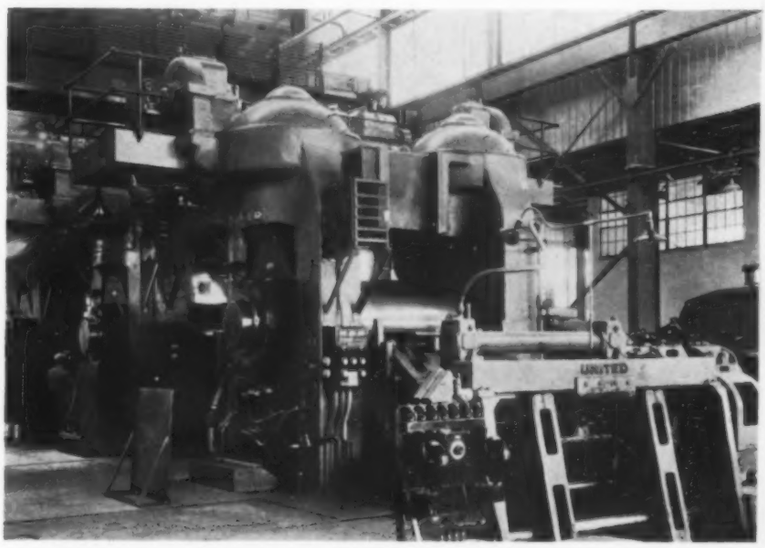
Figure 11—Variable Voltage Main Control Board for 42″ Five-Stand Tandem Cold Reduction Strip Mill.

The increased rolling speeds as indicated above can be utilized to the best advantage only when rolling long strips. Even with the most skilled operators and smoothest mill performance, there is considerable time lost in removing the finished coil from the reel and threading the next strip through the mill, and in accelerating to the rolling speed at the beginning of the strip and decelerating at the end of the strip. There is also usually a certain amount of off-gauge strip at each end. The percentage of lost time and percentage of off-gauge strip can obviously be greatly reduced with longer coils. The newer cold strip mills are laid out with reels and other equipment to permit handling coils weighing from 300 to 600 pounds per inch width, thus securing the maximum benefit from the high operating speeds.

Figure 12 is a general view from the entry end of the 80″ three-stand tandem mill at the Middletown plant of the American Rolling Mill Company, and shows the uncoiler and strip feeding mechanism by which the end of the strip is mechanically threaded into the mill. The mill stands are driven by three 1500 HP., 300/600 RPM., 600 volt, direct current motors, and the reel is driven by a 600 HP., 300/1050 RPM., 600 volt motor. The reel motor provides rated full load tension capacity of about 64,000 pounds up to 300 FPM. base speed, and 32,000 pounds at 600 FPM. maximum delivery speed. Observations indicate that this available tension capacity is fully utilized when rolling the wider material, although other similar mills apparently are operating quite successfully with much smaller capacity reels. Figure 13 is a closeup view of the No. 3 Stand, and shows the operators main master control and meter cabinet for the control of the No. 3 Stand and winding reel, and the master control of the entire mill. The No. 3 Stand screwdown control pushbuttons are also mounted on the left side of the master control cabinet.

The 54″ wide four-stand tandem cold reduction strip mill under construction at the Campbell plant of the Youngstown Sheet & Tube Company is an example of a special purpose mill for the rolling of strip material wider and heavier than normally rolled on tinplate mills, and narrower and lighter than can be economically rolled on the large heavy sheet gauge mills. The mill consists of four 54″ four-high roll stands, each driven by a 1250 HP., 300/600 RPM., 600 volt motor, and geared for a final delivery speed range of 600/1200 FPM., and a tension winding reel driven by a 225 HP., 225/900 RPM., 600 volt motor. The mill is expected to produce sheet material ranging from 24″ to 50″ wide, and from .015″ or even down to .012″, up to .025″ or .031″ thick. As indicated above the mill is geared for a maximum delivery speed of 1200 FPM., which is nearly twice as fast as most mills of this width, but necessary to enable high tonnage output when rolling the lighter range of gauges. The four-stand arrangement is also unique in a mill of this width, but is neces-

Figure 12 — Entry End of 80″ Three-Stand Tandem Cold Reduction Strip Mill.



sary to effect the required elongation which is intermediate between the usual sheet rolling which is accomplished in three stands and tinplate rolling which in most mills requires five stands.

The tension reel belt wrapper is a recently developed mechanical device which has greatly improved the performance of tandem cold reduction mills, and considerably increased their tonnage output. This device enables threading the end of the strip onto the tension reel with the reel running at practically the strip speed, thus permitting threading at strip speeds as high as 200 to 250 FPM. Since the reel is running at practically the strip speed there is no loop developed between the mill and reel, and the strip is brought under tension very quickly and with very little jerk, so that strip breakage is largely eliminated. Figure 14 shows the belt wrapper in position with the belt around the reel and the end of the strip just entering the reel. Figure 15 shows the belt wrapper withdrawn after several turns of strip have been wound on the reel, and the coil building up on the reel. The wrapper belt is entirely driven by its contact with the reel drum. The reel control connections are arranged so that the reel may be rotated backward while the finished coil is being pushed off, to assist in collapsing the reel and to prevent "telescoping" the inside turns of the coil.

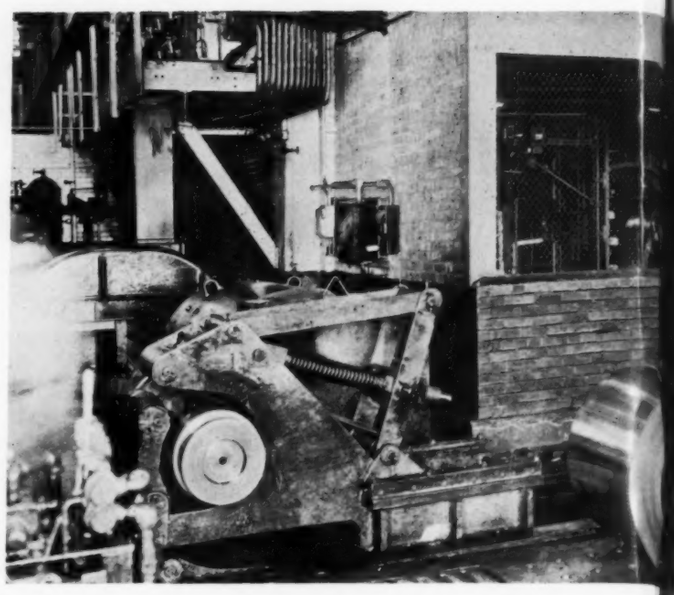
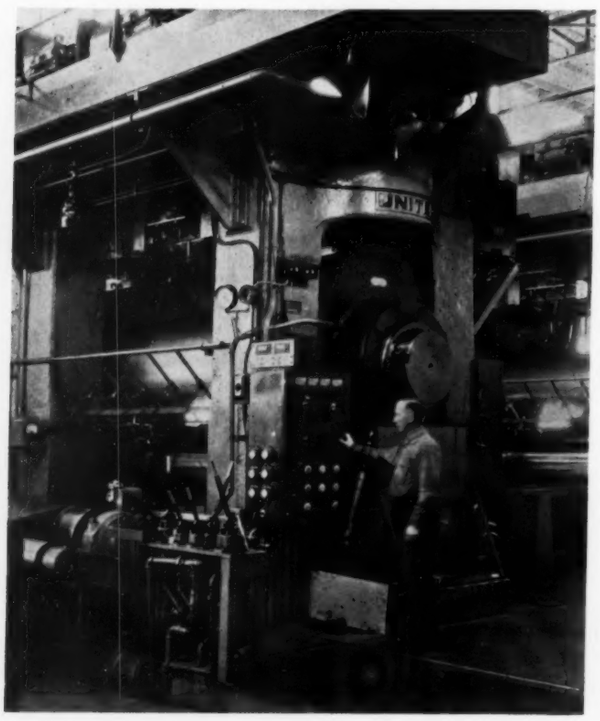


Figure 14—Tension Reel Belt Wrapper in place around Reel and end of Strip being threaded onto the Reel.

SKIN PASS MILLS

The installation of cold reduction strip mills was not at first paralleled by the installation of "skin pass" or "temper pass' strip mills, as the cold reduced strip was usually cut into short sheets which were skin passed in existing cold mills. A considerable proportion of the wider heavier gauge material is still cut into sheets after being cold reduced, and is annealed, temper rolled, and finished for shipment in sheet form. However, there are many economies in handling and processing coils rather than cut sheets, and some steel users require the finished strip in long coils, so that skin pass strip mills have been developed, and at the present time practically all of the narrow strip for tinplate, and much of the wider sheet gauge strip, is temper passed in coil form, requiring mills with unwinding and winding reels, and other tensioning machines.

Figure 13—Stand No. 3 of 80" Tandem Cold Reduction Strip Mill, Showing Operator's Master Control and Meter Cabinet.



It has been my observation and experience that strip temper rolling is usually a much more critical process than the cold reduction, and the skin pass mills and their associated reels and auxiliary tensioning equipment must be of the proper type, and be carefully operated, else satisfactory results will not be obtained. The strip has of course been reduced to practically its final finished gauge, and also has just been annealed and hence has lost much of its stiffness, so that extreme care is necessary to prevent wrinkling, buckling and other distortion of the strip as it is fed into the mill from the feed reel, and delivered from the mill to the winding reel. This is particularly true in the case of light gauge strip for tinplate, and equipment for temper rolling this class of strip has been the subject of much study and intensive development during the last two or three years.

The necessity for readily adjustable tension on the strip entering the mill and leaving the mill, has been recognized, and all mills have included a back tension feed reel and tension winding reel, with constant tension regulator control of the feed reel drag generator and winding reel motor to maintain constant front and back tension throughout the rolling of each coil. Operating

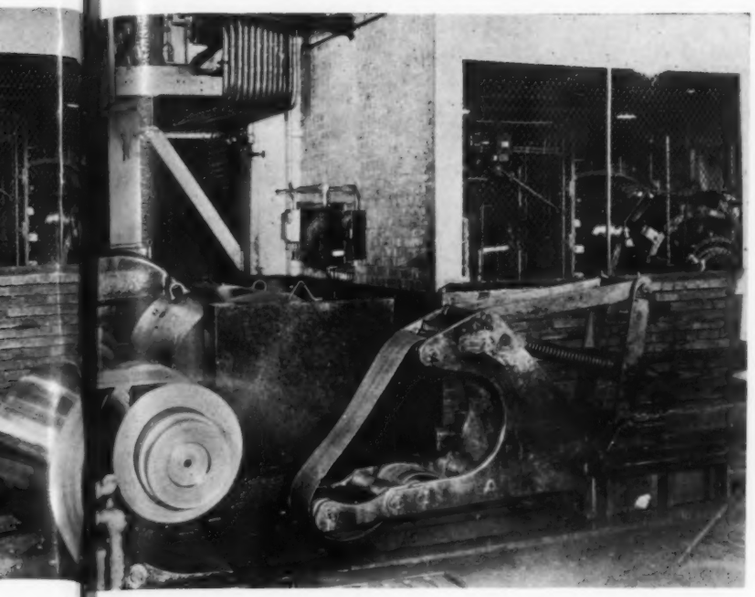


Figure 15—Tension Reel Belt Wrapper Withdrawn after the Strip has been Threaded onto the Reel.

experience has further disclosed that the best mill performance is obtained with relatively high entering and leaving tension, while the unwinding and winding reels perform better with only moderate strip tension. A number of mills have therefore been equipped with auxiliary tension rolls between the mill and the winding reel, to exert a considerable tension on the strip leaving the mill, while allowing the winding reel to exert only a moderate tension on the strip leaving the tension rolls.

The most recently completed mill, at the Indiana Harbor plant of the Youngstown Sheet & Tube Company, provides the maximum flexibility by having auxiliary tension rolls between the unwinding feed reel and the mill, as well as between the mill and the winding reel, so that the tension on the strip unwinding from the feed reel, the tension on the strip entering the mill, the tension on the strip leaving the mill, and the tension on the strip winding on the tension reel, may each be individually adjusted and regulated to the most favorable operating value. A somewhat detailed description of this mill and its electrical drive equipment may be of interest.

Figure 16 shows in elevation the arrangement of the mill, together with the winding and unwinding reels and entry and delivery tension rolls, and also the principal electrical connections to the main machines.

The ratings of the drive equipment follow:

Entry Side Unwinding Reel—Two 15 KW., 125 Volts, 450/1800 RPM., drag generators.
Entry Side Tension Rolls—125 KW., 250 Volts, 575/1150 RPM., drag generator.
Mill Working Rolls—300 HP., 250 Volts, 575/1150 RPM., Motor.
Delivery Side Tension Rolls—250 HP., 250 Volts, 575/1150 RPM. motor.
Delivery Side Winding Reel—150 HP., 250 Volts, 300/1200 RPM. motor.

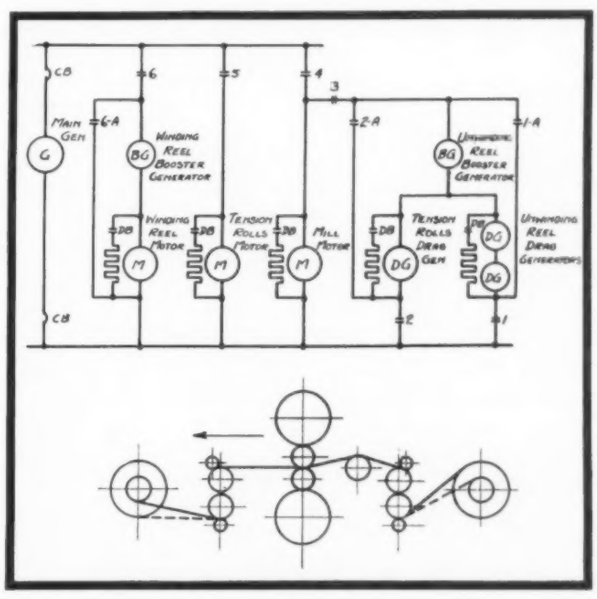
Variable voltage power is supplied from a 500 KW., 250 volt, main generator, and there are also two auxiliary motor generator sets, each comprising an induction driving motor, 15 KW. booster generator, and two small exciters used in conjunction with vibrating regulators to control the excitation of the tension roll and reel motors and drag generators.

The mill is arranged to permit using working rolls of any diameter between about 15¼ and 20 inches, and the gear ratios are selected to provide strip delivery speed range of 900/1200 FPM. at full voltage, and lower speeds by reduced voltage.

Constant current tension regulators are employed to regulate the current output from the unwinding reel drag generators and entry tension rolls drag generator, and the current input to the delivery tension rolls and winding reel motors, thus regulating the tension developed by each device, and permitting independent control of the tension at each point.

The operation is as follows: Assuming that a coil of strip has been clamped between the cones of the unwinding reel, the unwinding reel may be inched to feed the end of the strip up to the tension rolls and mill by closing contactor 1-A, and exciting the booster generator in the proper polarity. Similarly the entry side tension rolls may be inched by closing contactor 2-A, and exciting the booster generator, or the unwinding reel and entry tension rolls may be inched forward together by closing both contactors 1-A and 2-A, and exciting the booster generator. The mill and delivery tension rolls may be inched from the main generator by closing contactor 4 or 5, and properly exciting the main generator, and the winding reel may be inched to locate the reel clamp to receive the end of the strip by closing contactor 6-A, and properly exciting the winding reel booster generator. As soon

Figure 16—42″ Skin Pass Cold Strip Mill Arrangement of Mill, Tension Rolls and Reels, and Main Connections of Electrical Drive Equipment.



as the end of the strip is entered between the mill rolls, entry side stalled tension is obtained by closing contactors 1, 2 and 3, and exciting the booster generator in the reverse polarity, which will tend to rotate the unwinding reel and entry tension rolls backward and the mill forward, thus taking up any slack and establishing stalled tension. This also sets up the running connections for the unwinding reel and entry tension rolls. The mill and delivery tension rolls are now inched forward to advance the strip to the winding reel, the reel is started by closing contactor 6, and the entire drive brought up to speed by raising the main generator voltage. Provision is made to secure full running tension as soon as the mill starts by "jumping" the excitation of both booster generators, and the regulators are automatically recalibrated during acceleration and deceleration to compensate for reel and tension rolls inertia and maintain the same tension as during operation at constant speed.

Figure 17 shows the delivery side of this skin pass mill, taken during construction, and shows particularly well the operator's master control cabinet, and meter cabinet, mounted on the mill housings. Figure 18 shows the entry side of the mill, with the double cone type unwinding feed reel, and auxiliary control cabinet.

In the 42″ skin pass strip mill just described, the unwinding reel drag generators are standard coupled machines, and the reduction gearing, bearings, and low speed shafts, to support the coil clamping cone, were supplied as part of the mechanical equipment. A somewhat more compact arrangement which has been used on several mills utilizes gear generators, with the drag generator, reduction gearing, bearings, and low speed cone shaft, assembled into a single rugged compact unit. The gear case, low speed bearings, and low speed shaft upon which the clamping cone is mounted, must be of very rugged construction, entirely out of proportion to the size of the drag generator and

TABLE II

42″ Single Stand Reversible Cold Reduction Mill
Test Rolling 29½″ Wide x .082″ Thick, 7270 Lb. Coil, to 29½″ Wide x .0112″ Thick, Five Passes

1	Pass Number	0	1	2	3	4	5	
2	Strip Thickness	.082	.044	.025	.016	.0127	.0112	Inch
3	Cross section area	2.42	1.30	.738	.472	.375	.330	Inch
4	Reduction per pass		46.3	43.2	36.0	20.6	11.8	Sq. In.
5	Total elongation		1.86	3.28	5.12	6.46	7.32	Percent
6	Delivery speed		578	665	680	830	838	Ft./min.
7	Entry speed		310	378	435	660	740	Ft./min.
8	Delivery reel—volts		512	594	595	575	596	Volts
9	—amperes		390	360	300	300	240	Amperes
10	—kilowatts		200	214	178	172	143	Kilowatts
11	—HP. (Eff. = .92 x .97)		240	257	214	207	172	Horsepower
12	—Total tension		13,700	12,750	10,400	8,230	6,775	Pounds
13	—Tension lb./sq. in.		10,550	17,300	22,100	21,950	20,500	Lb./sq. in.
14	Mill rolls —volts		512	594	595	575	596	Volts
15	—amperes		2000	1460	930	920	390	Amperes
16	—kilowatts		1024	867	553	530	233	Kilowatts
17	—HP. (Eff. = .93 x .97)		1240	1050	670	642	282	Horsepower
18	Entry reel —Volts		254	354	362	481	474	Volts
19	—Amperes		0	350	370	340	335	Amperes
20	—Kilowatts		0	124	134	163	159	Kilowatts
21	—HP. (Eff. = .90 x .97)		0	190	206	250	244	Horsepower
22	—Total tension		0	16,600	15,600	12,500	10,900	Pounds
23	—Tension lb./sq. in.		0	12,750	21,100	26,500	29,100	Lb./sq. in.
24	Total net rolling HP. (11 + 17 — 21)		1480	1117	678	599	210	Horsepower
25	Net tons per hour		76.5	49.9	32.8	31.8	28.2	Net tons/hour
26	HP. hours per net ton—							
	a. Per Pass		19.4	22.5	20.6	18.8	7.5	HP. Hours/ton
	b. Total		19.4	41.9	62.5	81.3	88.8	HP. Hours/ton
27	Total net amperes (9 + 15 — 19)		2390	1470	860	880	295	Amperes
28	Kilowatts at 600 volts		1435	882	516	528	177	Kilowatts

torques to be transmitted, in order to carry the radial loads imposed due to the strip tension and the weight of the coil of strip, and to withstand the thrust loads imposed by clamping the coil between the opposed cones. Two 25 KW., 300/1200 RPM. units, with 10.5:1 ratio gear reduction, are now being supplied for the unwinding reel of a 98″ single stand mill. The reel will accommodate coils up to 60″ outside diameter, weighing up to 50,000 pounds. The steep angle roller thrust bearing is of capacity to permit coil clamping pressures up to 100,000 pounds.

MILL PERFORMANCE

Considerable data has been accumulated regarding power demands, energy consumption, and rolling rates, which may be of interest as indicating the performance of various types and sizes of mills, operating in various classes of work.

Table II shows a test on a 42″ single stand reversible cold reduction mill, rolling a 29½″ wide by .082″ thick, 7270 lb. coil, to 29½″ wide by .0112″ thick strip, for tinplate, in five passes. The first pass was made at 578 FPM. and the last pass at 838 FPM. This mill is capable of operating up to about 1100 FPM. and is normally operated at the top speed for the last two passes when good steel is available. Note that on the last three passes the delivery reel tension is held at about 20,000 to 22,000 pounds per square inch, while the entry reel tension is held at a somewhat higher value.

On this 42″ reversible type mill, normally rolling .082″ thick strip, 20″ to 36″ wide, to usual tinplate gauges, the best 24-hour output has been about 160 net finished tons. During 1936 the best monthly output was about 3300 net finished tons. The energy input to the main motor generator set varied from 93.5 to 132.1 kilowatt hours per net finished ton, the average for the year being 112.8.

On another 42″ single stand reversible mill installation, normally rolling from about .060″—.065″ thick strip, and finishing to usual tinplate gauges in three or four passes, the average monthly output for a three months period was about 3250 net tons, and the average input to the main motor generator set was about 98.0 kilowatt hours per net ton.

Table III shows a test on a 42″ five-stand tandem cold reduction strip mill, rolling 33″ wide by .074″ thick, 5500 lb. coil, to 33″ wide by .0108″ thick strip, for tinplate, at 1045 FPM. delivery speed from the No. 5 stand. The values of strip tension between stands could not be measured, however I have assumed 10,000 lb./sq. in. in between stands No. 1 and No. 2, 12,500 lb./sq. in. between stands No. 2 and No. 3, and 15,000 lb./sq. in. between stands No. 3 and No. 4 and between No. 4 and No. 5, in order to calculate the interchange of power and arrive at a figure of net rolling power for each stand. With these assumed values of tension between stands, the tension power is only about 20% of the total.

On this 42″ five-stand tandem mill, rolling .074″ thick hot strip to .0108″ thick strip for tinplate, the best 8 hour turn output has been about 200 net finished tons. The best month output was about 9200 net tons, with 102.5 KWH. per net ton input to the 2500 KW. main motor generator set.

On another 42″ five-stand tandem mill, geared for a maximum rated delivery speed of about 1200 FPM. and frequently operating above this rated maximum

TABLE III

42″ Five Stand Tandem Cold Strip Mill
Test—Rolling 33″ Wide x .074″ Thick, 5500 Lb. Coil, to 33″ Wide x .0108″ Thick, 1045 FPM.

1	Pass Number	0	1	2	3	4	5	Reel	Total	
2	Thickness after pass	.074	.0597	.0297	.0183	.0138	.0108			Inch
3	Cross section area	2.44	1.97	.98	.604	.455	.356			Sq. In.
4	Reduction per pass		19.3	50.3	38.4	24.5	21.7		85.4	Percent
5	Total elongation		1.24	2.49	4.05	5.37	6.86		6.86	Elongation
6	Strip delivery speed	152	189	380	615	820	1045			Ft./Min.
7	Net tons per hour								38.0	Tons/Hour
8	Indicated motor HP		190	870	830	670	910	120	3590	Horsepower
9	Estimated strip tension—									
	a. Per square inch			10,000	12,500	15,000	15,000	10,700		Lb./sq. in.
	b. Total			19,700	12,250	9,060	6,825	3,800		Pounds
10	Tension HP			110	140	170	170	120		HP.
11	Net rolling HP.		300	900	860	670	860		3590	Horsepower
12	HP. Hours per net ton—									
	a. Per pass		7.9	23.7	22.7	17.7	22.7			HP. hrs./ton
	b. Total		7.9	31.6	54.3	72.0	94.7		94.7	HP. hrs./ton

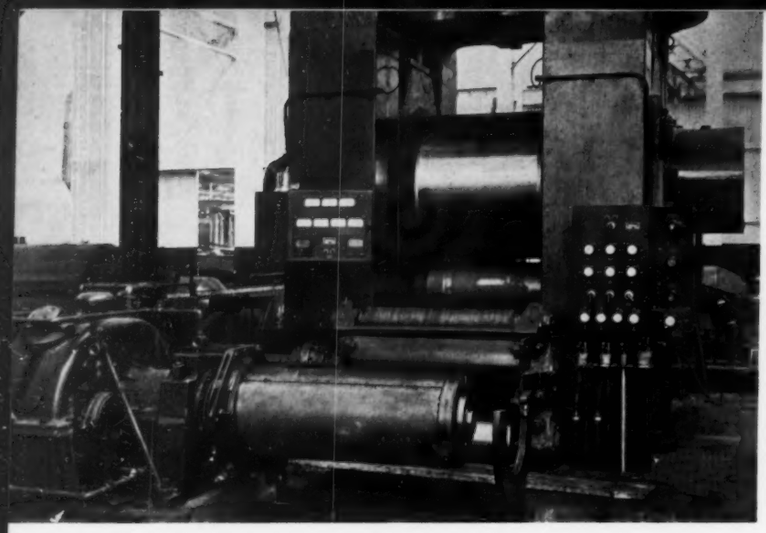


Figure 17—Delivery Side of 42″ Single Stand Skin Pass Mill.

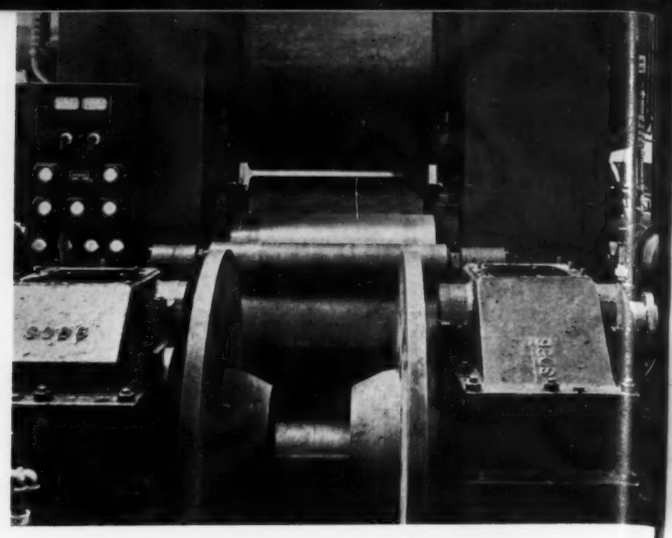


Figure 18—Entry Side of 42″ Single Stand Skin Pass Mill.

speed, 8 hour turn outputs as high as 235 net tons have been obtained, and the monthly output has exceeded 10,500 net tons. Over a three month period, the average input to the main motor generator set was about 112 KWH. per net ton.

Figure 19 shows the results of power tests on several different reversible and tandem type cold reduction mills, rolling low carbon steel strip for tinplate. Curve A was plotted from data obtained from a 42″ reversible mill, rolling 25″ to 34″ wide x .065″ thick to .010″ thick in four passes. Curve B was plotted from data obtained from a 42″ five-stand tandem mill, rolling 33″ wide x .077″ to .081″ thick, to .0088 to .0103″ thick, at about 1500 FPM. Curve D was plotted from data obtained from a 42″ four-stand tandem mill rolling 26″ to 31″ wide x .072″ thick, to .0086″ to .0102″ thick, at about 1150 FPM. Curve E was plotted from data obtained from a 42″ five-stand tandem mill, rolling 31″ to 35½″ wide x .074″ thick, to .0108″ to .012″ thick, at from 900 to 1100 FPM. Curve F was plotted from data obtained from a 42″ reversible mill rolling 29½″ wide x .082″ thick, to .0112″ thick in five passes. The heavy Curve C is a composite of these various tests, to show the average power which would be expected for normal cold reduction to tinplate.

Summarizing the above data for the cold reduction of strip for tinplate, we find that the average energy consumption is practically the same for rolling in either the single stand reversible or multiple stand tandem type mills. The net energy for the rolling work is about 95–100 horsepower hours per net ton, and the gross input to the main motor generator set is about 100-110 KWH. per net ton. With favorable orders and good rolling conditions, different single stand reversible mills have rolled about 3300 net tons per month, while tandem type mills will produce 10,000 or more net tons per month.

Figure 20 is the average curve plotted from nine different tests made over a period of several months on a three-stand tandem cold reduction mill, rolling various grades of steel strip, from 46½″ to 74″ wide x .093″ to .105″ thick, to .035″ to .043″ thick, at various delivery speeds from 210 to 450 FPM. During one month the maximum 24 hour day output was 875 net tons. The average gross input to the main motor generator set was 41.2 KWH. per net ton.

In another plant operating two three-stand tandem cold reduction mills, the combined monthly output from the two mills has reached about 31,500 net tons, and the average gross input to the main motor generator set, over a nine months period, was about 36.0 KWH. per net ton rolled.

One 75″ three-stand tandem cold reduction mill which has been fortunate in having very favorable rolling schedules, together with a smoothly operating mill and skilled operating crew, has achieved the very remarkable record of rolling 90 net tons in one hour, 637 net tons in an 8 hour turn, 1435 net tons in a 24 hour day, and over 28,000 net tons in a month.

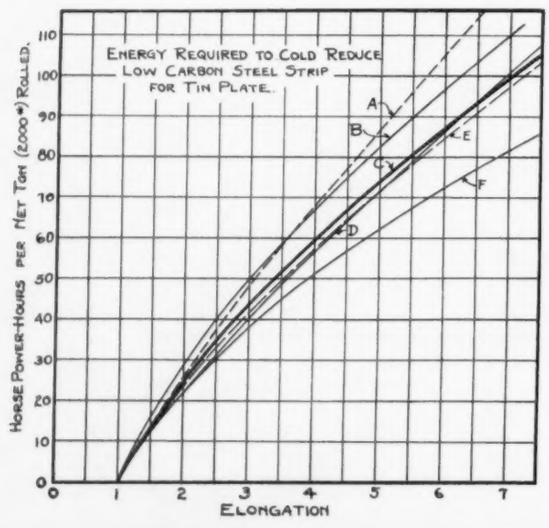
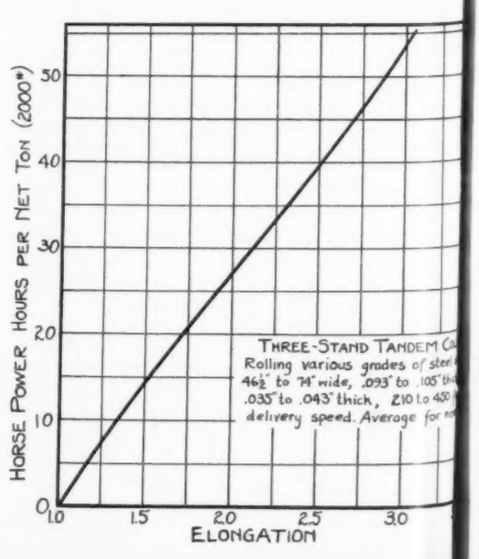


Figure 19—Energy Required to Cold Reduce Low Carbon Steel Strip for Tinplate.

(Left)

Figure 20—Energy Required to Cold Reduce Wide Steel Strip to usual Sheet Gauges.

(Right)



THE MEASUREMENT of the Frictional Characteristics of BRUSHES

By Dr. S. W. GLASS
Research Laboratories
National Carbon Company, Inc.
CLEVELAND, OHIO

▲ THE brush-commutator interface is a sliding contact, and one of the fundamental characteristics of a sliding contact is its frictional torque. The technical importance of reliable laboratory methods of measuring friction arises from the premise that a knowledge of the frictional properties of a brush is absolutely essential to a rational understanding of its operating behavior in commercial service. This view has been challenged in some quarters on the ground that there was insufficient evidence directly relating brush life or commutating behavior in the field with laboratory measurements of frictional torque and mechanical wear. The lack of a satisfactory correlation of this kind in spite of the efforts of many investigators is evidence enough of the difficulties encountered in this problem in the past. With the recent advent of brush grades of a degree of uniformity formerly believed impossible for commercial production, some of the previously uncontrolled variables have been eliminated, enabling considerable progress to be made toward the ultimate goal. This paper presents some of the steps that have been made which it is believed will aid in a better understanding of brush operation in general and specifically of electrographitic brushes made of lampblack.

Although entirely self-evident, the fact is frequently overlooked that the term "brush friction" or "coefficient of friction of a brush" is meaningless except in relation to some second material (the commutator or ring) under some set of operating conditions. In other words, we are dealing with some brush face sliding on some commutator surface. Which determines the frictional torque? The answer to this question is that for a given brush operating under a given set of conditions, the condition of the commutator surface is directly responsible for the magnitude of the frictional torque. This will be made evident from the following observations.

It has been observed that cleaning, polishing or sanding of the brush faces (independently of the commutator surface) is usually without any immediate effect upon the frictional torque—provided the sliding surfaces are kept at a constant temperature. On the other hand any cleaning, polishing, or abrasive action applied to the commutator surface itself will usually cause an immediate, though sometimes temporary, change in the frictional torque.

It is equally clear, however, that the physical and chemical properties of the brushes are important factors in controlling the physical character of the commutator surface and the chemical nature of the commutator film. While the brushes are usually the controlling factor in determining what the condition of the commutator surface shall be, there are many conditions of operation which cause changes in the interface surfaces with corresponding changes in frictional torque. Operating conditions involving abnormal commutator temperatures or abnormal electrical or mechanical conditions causing destructive arcing, or the presence of chemically active gases or vapors in the atmosphere may temporarily unbalance or completely destroy the normal surface conditions of both commutator and brush faces. Such changes may be either slow or rapid. Thus the frictional torque produced by the sliding contact of brushes on a commutator will be constant only if the total effect of brushes and operating conditions is such as to produce and maintain constant surface conditions at the interface. It has been found possible in the laboratory by proper control of such operating variables as spring pressure, current density, temperature, and atmosphere to quickly establish comparatively stable interface conditions which will give a reasonably constant and reproducible frictional torque for long periods of time.

The tests are made on 7.5 inch diameter rings made from seamless drawn copper tubing. Saw cuts across the face of the ring simulate the undercut slots of a commutator, hence the name "dummy commutator machine", although of course no commutation is involved. The rings, driven by a variable speed d.c. motor at a surface speed of 5200 feet per minute, are ground and finished before each series of tests by means of a commercial commutator grinding machine using only suitable commutator stones. Auxiliary electric heaters controlled through thermocouples by suitable

automatic regulators maintain the commutator at the desired temperature within —2°C.

Reaction type brush holders with a leading angle of 38° carry the four brushes, 1 x 0.5 inch in cross section, all of which operate on the same track. The load current through the two positive and the two negative brushes is supplied by a 10-volt plating generator through a variable resistor. The practice of using a single circuit, i. e., one positive and one negative brush, appears to be objectionable because it forces the entire load current to jump a gap between the brush and the commutator with every vibration of either brush. Under normal service conditions (except on the smallest machines) several brushes operate in parallel on each stud. Since the chances are very slight that all the brushes on any stud will leave the commutator surface simultaneously, the load current is shunted from the brushes making poor contact with the commutator at any given instant to the brushes making better contact, thus preventing any heavy arc discharge. This arrangement has the further advantage of increasing the ratio of the brush area to commutator area with the result that equilibrium between the brushes and commutator surface is obtained much more rapidly.

The brush holders are of standard design, made by a well known electrical manufacturer, but in order to attain satisfactory accuracy in our laboratory tests it was necessary to replace the mechanism for adjusting the spring tension. Whereas the original equipment had the usual adjustments of about 3 to 6 ounces for each step, the new arrangement allows the spring tension to be adjusted to any desired value within one-half ounce or less. Uniform spring pressure is necessary not only for the sake of uniform mechanical wear of the brushes but also to attain an even current distribution between the parallel brush circuits and, therefore, uniform and reproducible operating conditions for all of the brushes on test. Spring pressures are corrected for the angle of lead so as to represent: pounds (normal to the commutator) per square inch of contact area. By mounting the brush holders on arms which are statically balanced and free to rotate in ball bearings, the frictional torque can be measured directly by means of a spring.

Thermocouples of No. 36 wire inserted in small holes (No. 60 drill) in the brushes parallel with and about 1/16 inch from the face are used to measure the operating temperature of the interface. This temperature, which is usually the same as the average commutator temperature when the brushes are operating under no load, will generally become 5–20°C. higher than the commutator temperature as the result of the passage of the load current across the interface.

For reasons which will be discussed later, the dummy commutator machine is located in an air-conditioned room supplied with washed air at 70°F. and 50 per cent relative humidity.

The only practical way of relating measurements of friction, contact drop and mechanical wear on the dummy commutator to commercial conditions appears to be through the control of the interface temperature on the dummy commutator over the range of temperatures observed in commercial service. Measurements on generators and motors of various sizes and services

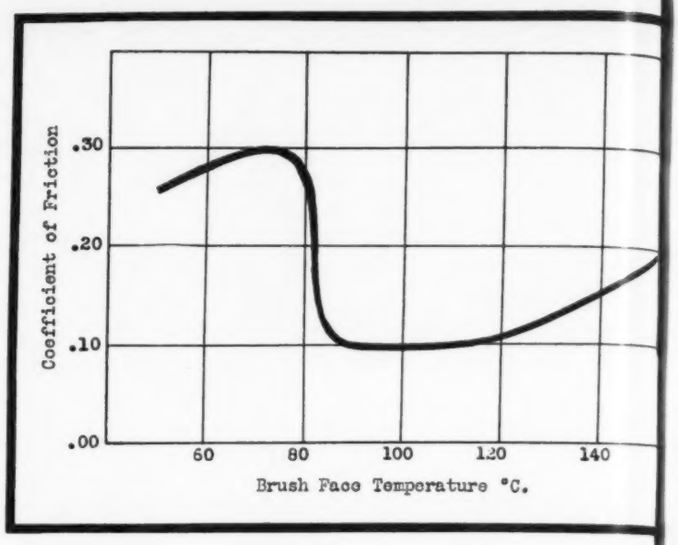


Figure 1

have shown interface temperatures from 50°C. up to 150°C. It is not believed that these represent the most extreme cases, but it seems that in order to satisfactorily define the frictional behavior of any brush the temperature curve of the frictional torque should be determined over this range.

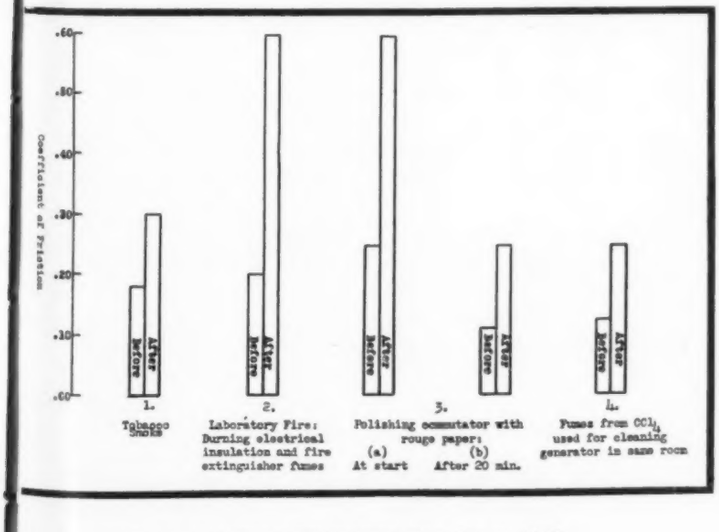
A correlation of these surface temperatures with the frictional torque for electrographitic brushes produces a friction-temperature curve of the type shown in Fig. 1. Tests have shown that the changes in the coefficient of friction as indicated by this curve are due only to the effect of temperature since practically identical curves are obtained whether the brushes are operating with load current or under no load conditions. This curve will not be duplicated exactly by all electrographitic brushes, but may be displaced slightly toward higher or lower temperatures or higher or lower frictional values depending on such things as the processes used in the manufacturing operations and the particular testing procedure used. Thus the minimum coefficient of friction in the relatively flat portion of the curve in the neighborhood of 100°C. may vary from 0.09 to 0.12, while the normal maximum at temperatures close to 70°C. may vary from 0.26 to 0.32. This three-fold change in friction occurs within a very narrow temperature range but does not usually take place instantaneously. There seems to be a definite lag period so that the heating and cooling curves generally resemble hysteresis curves unless the temperature changes are made very slowly. The data from a large number of tests indicate that this big change in friction occurs between 80°C. and 85°C., but by heating too rapidly it may occur at 90°C. or higher and by too rapid cooling at 75°C. or lower. One possible reason for such a delay in reaching the equilibrium condition may be the necessity for the brush to wear into face again after a temperature change, the out of face condition being the result of the difference in the coefficients of thermal expansion of the brush and commutator.

In order to determine whether this break in the friction-temperature curve was a characteristic of the

carbon film on the commutator and brush surfaces or of the copper surface itself, some measurements were made on another type machine of the friction between brush and steel and also between two pieces of the same brush. In the case of the carbon-steel interface a break in the curve was observed at approximately the same temperature as in the carbon-copper curve. The carbon-carbon interface gave similarly sharp changes in the frictional torque but at various temperatures ranging from 70° to 150°C. These latter experiments were not pursued further to determine the cause of these irregularities. However, all of these tests seem to indicate that the break in the friction-temperature curve is a characteristic of the brush sliding on the film which it forms on the surface of the copper or other material.

The importance of a knowledge of the interface temperature when dealing with the frictional characteristics of electrographitic lampblack-base brushes is clearly shown by the preceding portion of this paper. However, the measurement and control of this interface temperature will not alone insure accurate and reproducible values of frictional torque. The coefficient of friction is affected more or less temporarily but nevertheless to a very marked degree by what we choose to call "contact poisons". The effects of acid fumes, chlorine and other corrosive chemicals on the operation of rotating electrical equipment in chemical plants is too well known to need discussion here. Mention will be made of some of the other contact poisons which may be encountered. Perhaps the most common is tobacco smoke. For example, one or two puffs of cigarette smoke on the commutator will double the friction for a period of minutes. This is not due to high humidity, since no effect is observed when simply blowing on the commutator from the mouth. Smoke from other sources may be as harmful as that from tobacco. When some electrical wiring in the laboratory became so severely overloaded that the insulation began to burn, the resulting smoke and the fumes from the fire extinguisher caused a three-fold increase in friction. (See Fig. 2) A further striking example of a contact poison was observed when a little carbon tetrachloride was used to clean some apparatus on the other side of the large, well-ventilated laboratory room in which the dummy commutator machine was located. Although on a certain test the coefficient of friction had been practically constant for three days with a minimum of 0.09 and a maximum of 0.11, within five minutes after the use of the carbon tetrachloride the friction doubled to values of 0.20 to 0.25. Ten minutes later the commutator surface which had maintained a brown mirror polish began to show raw copper streaks. Likewise the brush faces which had shown a smooth slightly porous polished surface became grooved and roughened and showed pronounced copper picking. This highly unsatisfactory brush and commutator condition had not yet disappeared six hours later although the carbon tetrachloride was in use for only a few minutes. Moreover, the rate of brush wear during this six hour period was twice that of the average rate during the preceding three days. It is quite evident that the common practice of using carbon tetrachloride for cleaning electrical machinery is highly objectionable from the standpoint of satisfactory brush performance. In this connection also it might be noted that carbon tetrachloride is one of the ingredients of some of the polishes for brass and other metals.

Figure 2



It has been found that the erratic and very high frictional torque values obtained at the start of many tests were the result of using rouge paper to polish the commutator subsequent to the stoning operation. Avoidance of this finishing process was found to result in the almost immediate establishment of the normal frictional torque values corresponding to the interface temperature, subject to the variations characteristic of the brush. The coefficient of friction is also sensitive to paint fumes, turpentine, acetone and alcohol. Previous observations in commercial service where inexplicable changes have suddenly occurred in the brush friction and in the commutator appearance are probably best explained in a similar manner as the result of contact poisons in contaminated atmospheres. Treatment of the commutator surface with either oxidizing or reducing agents has been found to produce immediate but exactly opposite effects upon the friction and contact drop. In applying these reagents to the commutator the brushes were first lifted and the excess of the reagent was carefully removed before lowering the brushes. In all cases the measurement of frictional torque was made at a brush temperature of about 125°C. Using methyl alcohol as the reducing agent caused the friction of a lampblack base brush to rise to a coefficient of 0.5. When hydrogen peroxide was then applied to this commutator, the friction immediately dropped to about 0.13. These alterations in the coefficient of friction between 0.50 and 0.13 could be reproduced at will. It is noteworthy that the hydrogen peroxide should produce a coefficient of friction which closely approximates the normal friction of this brush grade at 125°C., whereas the action of methyl alcohol, a reducing agent, produced an abnormally high friction. This suggests that under normal operating conditions the commutator film is probably in a partially oxidized state, caused by the action of the air on the heated

surface. It also suggests that the effect of smoke fumes and similar organic compounds in producing high friction probably results from their reducing action upon the oxides in the commutator film. The effect upon the contact drop was in exactly the reverse direction, increasing with oxidation and decreasing with reduction.

From a consideration of the complex chemistry of copper it is not at all surprising that the physical and chemical equilibria between carbon brush faces and a copper commutator should be so delicately balanced and so easily upset. High speed commutators operate with a surface speed of a mile a minute or more. At these speeds the impacts resulting from brush vibration necessarily cause the formation of a surface film of "worked" copper. The hardening of the copper surface under brush impact is quite easily detected by observing the increased resistance to abrasion with sandpaper. The hardened copper surface is glassy, the sandpaper does not easily scratch it, and it has a low frictional torque. Since this marked resistance to abrasion does not develop on those portions of the commutator surface upon which the brushes are not riding, the frictional torque against sandpaper here being very pronounced, the surface hardening can not be due entirely to heat or oxidation. The hardened, or so-called "amorphous", copper is unstable, however, and is even more susceptible than ordinary copper to attack by various chemicals. Moreover, this chemical sensitivity increases rapidly with temperature.

Now it is apparent that under normal brush operating conditions the commutator surface is subjected to a number of directly opposing chemical reactions, as for example:

(a) The amorphous copper film may tend to become oxidized by the air, especially at temperatures of 100°C. and higher.

(b) The thin film of graphite or amorphous carbon which is superposed upon the copper surface by the carbon brush may conceivably act as a reducing agent for the oxides of copper.

(c) The contact drop under the positive and negative brushes tends to set up alternate electrolytic reducing and oxidizing potentials on the commutator surface, which are frequently unbalanced as between positive and negative brushes.

(d) Chemical impurities from the ash in the brush may accumulate in the commutator film, or gradually react with it. Or such impurities may catalytically accelerate the rate of oxidation or of reduction by one of the reactions mentioned above.

These considerations are sufficient to indicate the possibility of commutator film instability and the frequent upsets in brush-commutator equilibria by factors for which the brush may or may not be directly responsible.

Reference has already been made to the interdependence of contact drop and frictional torque. Seldom does any marked change in friction occur without some change also occurring in the contact drop. As they are both surface film phenomena this close interrelation between the two is not at all surprising. Although both properties seem to be affected simultaneously by any given surface change, the changes in the two are not necessarily in the same direction. As we have already seen, for normal lampblack base brushes the temperature coefficient of the frictional torque is positive at temperatures below 70°C., becomes sharply negative at about 80°C., is close to zero from about 90° to 120°C., and becomes positive again at still higher temperatures. On the other hand, throughout this same range of temperatures the temperature coefficient of the contact drop is always negative. But the percentage change in contact drop with temperature is much less at high current densities than at low current densities. Thus we see that the two values may sometimes move together and sometimes in opposite directions. This explains the observations which are sometimes made of a higher contact drop at low loads than at high loads, seemingly a paradox unless the temperature relationships are considered.

The effects on the rate of brush wear of changes in the frictional torque are likewise seemingly contradictory at times. In many cases the rate of wear is roughly proportional to the frictional work done at the interface, while in other cases a large increase in friction may be accompanied by a decrease in brush wear. To explain such apparent discrepancies, one must remember that two different kinds of friction may be involved. One kind is an abnormal or "roller" friction, in which small particles from the brush face act as roller bearings between the brush and commutator surfaces. In this case an extremely low frictional torque is associated with an extremely high rate of brush wear. The second kind of friction is the normal one in which the brush face makes a sliding contact with the commutator. Even in this case, however, the rate of wear is not necessarily proportional to the "work" done on the contact surfaces or the heat evolved. This will be obvious by an analogy with the action of cutting tools. The speed of cutting is measurable by the amount of power expended or by the heat evolved provided the cutting edge of the tool remains constant but not otherwise. Similarly the rate of wear of the brush or commutator may be expected to be proportional to the frictional work done or the heat evolved only if the changes in frictional torque involve no substantial changes in the abrasive properties of the contacting surfaces.

Thus we see that the relationships between coefficient of friction, contact drop, and rate of brush wear are quite complex. On the basis of the experimental observations which are discussed in this paper, it is our belief that a knowledge of the temperature changes occurring at the brush-commutator interface is absolutely essential for any intelligent understanding of the variations in brush performance which are ordinarily associated with changes in operating conditions in commercial service.

FUNDAMENTALS of SAFETY and Accident Prevention in Steel Plants

By L. H. BURNETT, Vice President
Carnegie-Illinois Steel Corp.

Presented before the Annual Meeting of American Iron and Steel Institute, New York City, May 27, 1937

▲ THE American safety movement definitely started more than 30 years ago. It, perhaps, had its inception in the action of several states in passing certain legislation in the interest of safety as far back as 60 years ago. Massachusetts and New York enacted laws requiring the safeguarding of machinery and safety inspection of factories in 1887. In 1899 the New York Bureau of Labor issued a report on industrial accidents and employers' liability. Before 1900 a number of other states had passed similar legislation. Some liability insurance companies inspected insured factories and some individual employers initiated safety work in their plants. In general, however, during those early years efforts towards safety and accident prevention were scattered and there seems to have been very little appreciation of the employer's responsibility to prevent accidents or even of the feasibility of accident prevention, and both the frequency and severity of industrial accidents were extremely high.

L. H. BURNETT

The real, concerted safety movement may be said to have begun about 1907, stimulated by the severe criticism of the public press at that time, the increasing liberality of courts in granting compensation to injured workmen, and the vigorous safety campaign launched by the United States Steel Corporation and a number of other leading corporations.

In April 1908 the Central Committee on Safety was formed by the Steel Corporation and it soon became an important clearing house for all of its many units. It is reported that at the end of the first two years of activity of the Committee approximately 6,000 safety recommendations had been made, of which 93 per cent were adopted.

In 1907 the American Institute of Social Sciences started the American Museum of Safety in New York City. The museum was incorporated in 1911 and began at once an aggressive educational campaign on safety. In 1912 it was given permission by the New York City Board of Education to carry its educational work into the public schools.

Perhaps the first technical association to appoint a safety committee was the Association of Iron and Steel Electrical Engineers, formed in 1907.

That Association was among the pioneers in organized accident prevention work, devoting its time and energy especially to the elimination of hazards involved in electrical operation of steel mills.

It was the first large organization to realize the necessity for the formation of a national organization "for the promotion of safety to human life," and at its convention in Milwaukee, held in October 1912, it conducted the First Co-Operative Safety Congress and appointed a committee composed of industrial leaders and federal and state officials "to organize and to create a permanent body devoted to the promotion of safety to human life in the industries of the United States."

The result of this resolution was the formation of the National Safety Council, which has become the largest and most influential safety organization in the world. It has extended its influence and assistance far beyond the industrial field, and today is composed of twenty-seven sections, embracing practically every form of human endeavor.

The National Safety Council was not only founded and organized but fostered and financed by the iron and steel industry, until it became well and firmly established. The Metals Section of the Council is among the largest and most active today and some of its important contributions to the industry have been the compilation of safe practice pamphlets; the furnishing of reliable accident statistics; the promotion

and formation of safety codes, and the establishment and maintenance of local councils.

That great organization with its thousands of members in various branches of industry and commerce has earned the respect and confidence of the public, and recently celebrated its twenty-fifth anniversary of most worthy and valuable accomplishments in the field of safety and welfare. Our industry heartily joins in wishing the National Safety Council many more years of success and usefulness.

The safety movement in the steel industry was officially recognized when the American Iron and Steel Institute included two addresses on safety and welfare in the program for its general meeting in May 1912. The papers were published in the 1912 Year Book of the Institute.

Together with the National Safety Council, various federal and state governmental agencies dealing with labor, and various employers' associations in industry, have become important sources of information and statistical data on industrial accidents in the United States.

Before compensation for accidents in industry had been inaugurated in the United States, the Bureau of Labor Statistics had been making an annual study (begun in 1910) of accidents and accident prevention in the iron and steel industry. In 1926 the Bureau began the collection on a comprehensive scale of industrial accidents in selected manufacturing industries. The scope of this work has been expanded to include approximately 30 industry groups, and approximately 55 per cent of the workers in those industries are now covered in the Bureau's industrial accident data.

While both the National Council and the Labor Bureau are very helpful and effective in safety and accident prevention work, it may be said that inasmuch as the reports of the National Safety Council cover mainly the experience of its member establishments, all of which are presumably interested and active in safety promotion, it may consequently present more favorable results than the survey of the Bureau of Labor Statistics, the coverage of which is probably more general in character. Also the National Safety Council includes in its figures industries other than manufacturing, and clerical employees as well as wage earners.

For this manuscript, however, the author has drawn freely from the literature of both the Bureau and the Council for information and statistics, and even though in every instance credit may not be specifically acknowledged, those familiar with such literature will readily recognize the passages.

It is thus seen that more than thirty years ago the iron and steel industry declared war upon industrial accidents. At that time the industry was classed as extra hazardous and the public, with good reason, considered the job of the steel worker an unusually dangerous occupation. As in the case of most wars, our war on accidents began as a mere skirmish conducted by a few faithful pioneers who realized that something must be done about the many injuries suffered by steel workers. The mass attacks upon the common enemy were to come much later, when it was fully realized that in order to win the battle it would be necessary to enlist the active services of every man in the industry.

Safety began as a purely humanitarian measure, to save lives and limbs, and to prevent pain, sorrow and suffering. There was not at the start much thought of saving money or improving efficiency. The enactment of workmen's compensation laws, however, from 1911 onward, which acted to throw a large part of the financial costs of accidents directly upon the employers, brought the matters of efficiency and economy to the front and gave another strong stimulus to the further development of safety and accident prevention. The movement has gone forward in practically every industry in every state and has become a permanent and important feature of every industrial relations program.

It is fortunate that the high ideals exhibited at the beginning of the movement have been maintained throughout the years. It has always been easy to obtain the necessary appropriations for real safety work. Safety, however, has paid a thousand times over and will continue to produce dividends of peace, happiness, contentment and money to ourselves and to our employees and their families.

EARLY ACCIDENT EXPERIENCE IN THE STEEL INDUSTRY

Although accurate statistics are lacking as to the number, kind and severity of accidents in the iron and steel industry as long as thirty or more years ago, it is known that there are now only about one-ninth as many accidents per million man-hours worked as there were thirty years ago, and the number of days lost per year by such accidents has decreased to only one-third as many.

The Department of Labor reports that in 1907 there were 82.06 accidents in the steel industry for every 1,000,000 man-hours worked, and 6.9 days working time was being lost by injured employees for every 1000 man-hours worked. Since that year the general trend in both frequency and severity has been sharply downward, and only in occasional years has it turned slightly upward. In 1935, the last year for which complete records are available, the frequency rate was only 8.86, or only 10.8 per cent of the rate in 1907, and the severity rate in 1935 was only 2.04, or only 29.5 per cent of the rate in 1907.

The steel industry was among the first to realize that industrial accidents were entirely too frequent; that too many men were being killed or seriously injured, and that it was the duty of management to make every possible effort to seek ways and means to improve conditions.

It is to the everlasting credit of the leaders of the industry and indicative of their wisdom and common sense that they have gladly assumed their responsibility and have devoted their time and energy to safety work, and have spent millions of dollars in making their plants as safe and comfortable as engineering skill and ability can make them.

From the inception of the campaign, the steel industry has earned and kept its place of leadership in safety and has served as an inspiration and example, not only to other industries but also to legislators and officials who make our laws. Many of the laws on the statute

TABLE I.

Changes in Occupational Injury Rates Since 1926

(In each industry, comparisons are made with the year which has an index number of 100. Index numbers above 100 show increases; below 100, decreases.)

	Frequency Rate Index Numbers										Severity Rate Index Numbers									
Industry	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935
All Industries	100.0	86.6	77.2	74.1	55.6	45.5	38.5	41.2	43.2	38.9	100.0	83.9	83.5	84.2	79.1	68.8	64.7	60.6	63.4	56.6
Automobiles	100.0	79.3	83.9	87.7	54.8	57.7	45.5	61.4	67.1	62.7	100.0	66.2	80.6	79.4	79.4	56.2	89.3	92.1	103.7	91.4
Cement	100.0	71.4	51.5	47.9	35.5	32.4	26.7	26.4	35.2	33.5	100.0	77.5	83.9	91.5	51.3	79.5	50.2	45.7	71.9	49.5
Clay products	....	....	100.0	95.2	80.8	77.5	73.1	92.4	83.7	79.6	....	....	100.0	40.7	60.3	187.6	18.0	53.7	53.3	64.7
Chemical	100.0	92.0	85.6	78.1	68.3	50.5	43.5	44.4	42.1	36.5	100.0	84.9	90.7	69.6	82.7	79.6	92.3	83.1	88.3	49.4
Construction	100.0	90.0	85.4	74.0	70.5	67.9	67.4	76.5	50.2	42.3	100.0	125.7	87.6	78.4	81.4	72.3	54.7	52.3	41.4	38.3
Electric railway	....	100.0	103.8	92.2	76.9	72.4	52.7	50.5	51.2	47.5	....	100.0	169.3	127.3	94.6	75.4	84.5	68.9	71.1	72.6
Food	100.0	86.7	79.8	72.5	61.9	58.6	53.1	57.3	60.4	63.9	100.0	89.1	84.5	114.7	129.9	122.4	90.6	101.9	97.7	100.8
Foundry	100.0	93.8	86.6	86.2	55.2	40.3	42.8	40.4	39.4	39.5	100.0	65.2	50.0	48.8	47.6	41.5	47.5	26.8	40.1	18.8
Glass	....	....	....	100.0	74.4	68.8	55.3	55.5	60.3	61.5	....	....	....	100.0	115.2	68.9	91.8	51.8	101.6	76.2
Laundry	....	....	100.0	100.5	66.6	42.6	31.6	47.7	46.0	62.2	....	....	100.0	181.5	74.4	287.4	7.8	17.1	118.3	9.9
Lumbering	100.0	95.8	89.7	85.9	75.4	66.9	59.2	74.3	77.8	59.7	100.0	39.0	57.9	56.1	48.1	40.5	51.0	42.6	52.3	47.1
Machinery	100.0	85.3	76.3	85.7	64.6	45.6	38.6	50.3	51.0	57.4	100.0	75.2	60.1	75.5	67.1	60.7	58.7	51.7	57.0	54.9
Meat packing	....	....	100.0	67.4	48.3	41.2	34.9	42.6	53.3	40.0	....	....	100.0	61.4	38.4	37.7	42.8	44.7	55.2	56.3
Metal products (misc.)	100.0	66.1	68.0	68.5	43.8	33.6	34.8	38.3	39.7	38.1	100.0	71.8	76.0	84.9	66.4	59.8	57.5	54.3	69.8	52.8
Mining	100.0	108.7	102.2	95.7	99.7	92.8	84.3	83.6	85.4	79.9	100.0	137.9	146.7	130.0	142.2	151.4	167.0	151.2	185.6	179.0
Non-ferrous metals	100.0	78.4	78.0	81.0	55.0	38.6	38.9	47.9	43.9	48.1	100.0	72.5	81.3	155.1	102.3	61.2	68.0	84.3	61.4	67.7
Paper and pulp	100.0	84.8	69.6	68.3	56.2	46.2	39.4	43.1	41.9	35.6	100.0	70.4	79.0	66.1	64.2	54.3	66.5	53.6	62.7	49.3
Petroleum	100.0	88.5	78.0	83.7	56.8	41.5	35.3	36.8	40.3	38.3	100.0	108.1	122.2	123.1	117.9	103.8	95.2	90.2	82.7	69.4
Printing and publishing	100.0	80.6	78.9	78.0	67.7	65.9	48.4	37.3	45.3	47.6	100.0	9.7	22.5	41.2	33.6	15.1	8.7	16.3	27.8	16.9
Public utilities	100.0	81.0	64.2	55.0	39.3	28.1	20.8	19.4	21.9	20.9	100.0	78.3	71.9	67.1	53.3	39.3	38.3	31.7	34.3	33.9
Quarry	100.0	103.4	81.9	82.8	62.3	61.3	53.5	49.0	44.3	32.4	100.0	72.6	72.3	118.7	46.1	89.5	34.7	32.8	18.2	8.5
Refrigeration	....	....	100.0	87.6	70.8	57.2	40.2	42.8	46.1	40.1	....	....	100.0	127.4	102.0	45.1	54.5	32.3	23.6	86.8
Rubber	100.0	89.7	75.1	60.5	40.8	36.7	34.2	38.0	30.7	28.2	100.0	61.2	69.9	79.6	60.7	64.7	48.0	68.4	48.3	31.4
Sheet metal	100.0	104.7	105.0	102.0	72.4	67.3	56.3	60.9	61.1	59.7	100.0	84.2	84.2	83.1	66.5	63.2	39.1	54.4	51.3	37.7
Steel	**100.0**	**77.9**	**67.0**	**64.3**	**44.8**	**38.7**	**36.8**	**44.2**	**41.1**	**33.8**	**100.0**	**83.9**	**85.7**	**102.4**	**92.8**	**80.2**	**63.2**	**72.4**	**76.2**	**75.4**
Tanning and leather	100.0	95.9	99.6	84.9	68.4	62.2	45.8	57.0	61.8	59.5	100.0	68.9	51.5	161.7	197.8	90.3	55.2	73.8	169.4	83.8
Textile	100.0	96.6	91.9	89.2	71.6	66.6	65.4	65.1	67.9	53.3	100.0	80.9	110.0	108.1	164.2	145.6	101.7	85.1	116.8	132.9
Tobacco	....	....	....	100.0	90.5	111.2	66.0	60.5	121.3	59.2	....	....	....	100.0	23.1	21.3	21.3	6.1	0.5	1.0
Woodworking	100.0	71.2	68.1	70.0	58.0	56.2	47.8	53.4	44.4	62.7	100.0	44.5	58.5	86.4	97.6	41.1	99.5	110.8	76.7	75.1
Marine	....	100.0	79.5	64.9	65.4	53.2	36.6	32.3	32.0	24.9	....	100.0	87.1	78.5	91.9	96.3	72.7	68.3	73.4	86.8

Source: Individual company reports to the National Safety Council.

books of our federal and state governments, with reference to safety, sanitation and welfare, are actual declarations of policies which were first adopted and practiced by the steel industry.

It is a tradition in the industry that no matter how difficult the task may be, some way can be found to accomplish it and do a good job, and while there cannot be any permanent solution of the safety problem, we can and will keep abreast of the times and with the progress and changes made in construction and operation, and will continue to make some gain each year.

Progress has been made through the difficult process of trial and error, rejecting the bad and retaining the good, and while we have experienced some disappointments and setbacks, the war against accidents has never faltered, and the industry may take justifiable pride in the results which have been achieved.

In 1935, the latest year for which the National Safety Council has published complete data, only six of thirty industries reporting to the Council had proportionately fewer accidents than the steel industry. Of these six, only the cement industry is closely comparable with steel in manufacturing heavy products on a mass production basis. The five others were the tobacco, laundry, rubber, printing and textile industries. With respect to the severity of accidents, which reflects the number of days lost through injuries, the steel industry ranks twenty-fifth, among thirty industries.

Progress made by the steel industry in its campaign to reduce the number of accidents is well illustrated in Table I which presents the change in occupational injury rates for thirty industries between 1926 and 1935. It will be noted that the percentage reduction in the frequency rate in the steel industry during that period was 66.2, whereas for all industries combined it was 61.1. Only five industries showed a bigger reduction in frequency than did steel.

These figures are impressive. They prove that the safety movement in the steel industry has saved thousands of lives and has prevented many thousands of serious accidents which would have resulted in permanent total and partial disability. The reduction in accidents in steel plants has been so great that the manufacture of iron and steel is no longer considered as especially hazardous and the average mill man is no longer required to pay an extra premium for life or accident insurance. He is now a preferred risk and is much safer in a modern steel plant than on the highway and safer even than in his home.

Each new development has brought its own lesson and, in order to determine the fundamentals of safety and accident prevention in steel plants, it is necessary to examine the various steps which have been taken from time to time and their effect upon the results which have been obtained.

It was the firm belief of those who were active in the early days of the safety campaign that the thorough covering of all gear wheels and other moving parts of machinery would prevent the great majority of accidents. It was mistakenly assumed that practically al industrial accidents were due to unsafe working condi tions and, therefore, preventable. The results obtained,

however, were disappointing. While such work prevented many accidents, it was found that safeguarding alone was not sufficient. We had failed to give due consideration to the human element. The real value of thorough mechanical safeguarding cannot be underestimated, however, and strict adherence to this policy has been largely responsible for the marvelous improvements and changes that have been made in our plants in order to provide a safe environment for our employees.

It has always been a primary duty of the employer to provide a reasonably safe place in which to work. Thirty years ago this obligation was fulfilled by furnishing a place which did not present unusual dangers or unexpected pitfalls. The modern conception of a safe place to work, however, is much broader and includes practically every known safeguard, not only as applied to machinery but also to the person. Today a safe plant must be clean and well ventilated, must have clear and well marked aisles, safe stairways and walkways, be well lighted and have an ample supply of good drinking water at the proper temperature. There must be proper sanitary conditions and expert medical and surgical service at hand. Where and when necessary, employees should wear safety shoes, should be supplied with suitable goggles, as well as protective clothing and respirators in certain occupations.

The application of engineering skill has been a very potent factor in the reduction of the number of accidents in the steel industry, and particularly in connection with the reduction of the high severity rate of accidents. In modern practice the complete layout, as well as detailed plans and specifications, for all new construction is carefully checked by engineers for safety, to insure proper clearances and to provide ample spaces for the work to be performed. All orders and specifications for new mills, furnaces, elevators, cranes and all other machinery is similarly examined to see that the necessary safeguards are provided and carried out in the final construction. The degree of improvement in working conditions and the extent of reduction in the frequency and particularly in the severity of accidents through the use of such engineering talent are among the most outstanding of accomplishments in the safety movement. They are really impressive to one who has followed this development during the past 25 or 30 years.

Discouraging results of early attempts at safeguarding did not prevent those who were actively engaged in safety work from adopting other methods for the prevention of industrial accidents. A study of actual cases showed clearly that only a portion of the accidents were due to machines and that many of them were caused by the ignorance, carelessness and negligence of the worker himself. The problem, therefore, was to sell the safety idea to the steel worker. Many of them were convinced that accidents were inevitable and that the employer was not sincere in his efforts to prevent them.

The younger men in the industry today can have only a little conception of the open and active hostility to safety displayed by thousands of employees, as well as many foremen and other supervisory forces, in those early days. They took great pride in being "hard boiled" and it was their philosophy that the other fellow might get hurt, but that nothing could happen to them. They gloried in their ability to take care of themselves.

A general campaign of education and publicity was, therefore, begun many years ago and is going on today with such changes and modifications from time to time as actual experience has dictated. The general purpose was to dispel the idea that accidents are inevitable and just happen and that nothing can be done about it, and to enlist the active support and individual cooperation of every employee from the highest to the lowest.

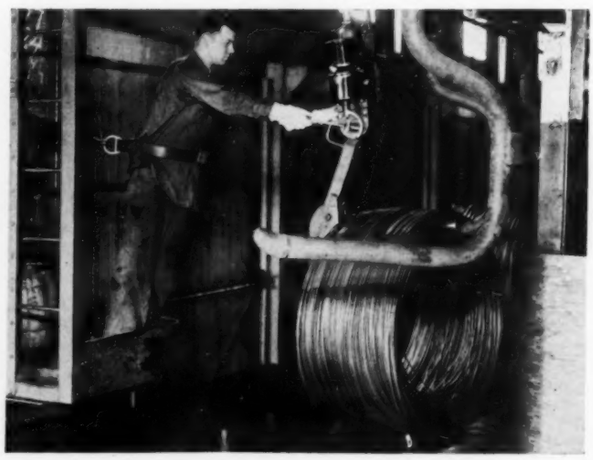
The principal features of the educational campaign and those which have been found to be most effective are:

(a) Mass meetings at which a talk on safety is given, together with suitable motion pictures and other forms of entertainment. Members of the families of employees are often invited. Such meetings produce best results when held at the beginning of a general safety campaign.

(b) Safety posters displayed upon plant bulletin boards have proved to be an excellent means of selling the safety idea, especially when such posters are of attractive design and carry a real safety story. In this connection, it would be ungrateful on our part if we failed to recognize the valuable service rendered by the National Safety Council in providing a remarkable poster service, as well as a beautiful annual safety calendar and other forms of safety publicity. That fine organization, the offspring of a technical association in the iron and steel industry, has earned and maintained a leading position in all forms of accident prevention, and naturally has been especially active in our own industry.

(c) Safety contests among various departments of a plant or company, in which a suitable trophy or prize is awarded to the winner, have proved to be very valuable activities in stimulating and in maintaining interest in accident prevention. Where properly conducted, a spirit of friendly but intense rivalry has been built up and in some cases reached such a degree of rivalry that the man who suffered an accident himself or injured one of his fellow workmen, through carelessness or negligence, was held by the employees them-

Note the safety belt worn around the waist of the workman as he operates an airplane crane at the new continuous rod mills of the American Steel and Wire Company at Joliet, Illinois



selves to be a real menace to the entire working force, and an undesirable workman.

(d) Job analysis and job training are important features of safety work as applied to apprentices and other new employees, and special attention has almost everywhere been given to such employees while they are being broken in to their new jobs.

The educational campaign had its inception in the fact that safety is not a job for one man or a single group of men, but must have the active support of the entire working force, and the most successful safety programs have usually been the ones which have included the greatest number of employees.

A definite safety organization has been found to be essential in securing and maintaining the interest and cooperation of the employees. A safety organization in a large plant may consist of one or more safety engineers; a plant safety committee, consisting of department heads; department committees, consisting of foremen and supervisors, and workmen's committees. It has been found advisable to rotate the men on the workmen's committees in order to have as many employees as possible actually engaged in safety work.

It is the duty of such committees to study accidents in order to determine their cause and prevent their recurrence; to make periodic inspections of the plant and to seek out and eliminate unsafe practices. A careful and continuous study of dangerous practices and their elimination is essential. It is easy to sell the safety idea to the man who is actively engaged in the work.

Up to the time of the formation of safety committees, the responsibility for accident prevention had been considered as something entirely separate and apart from regular daily operations. The work of the safety committees gradually brought about a realization that the prevention of accidents was properly a function of the operating department, and it has been found that where the department gives just as much attention to safety as it does to the quantity and quality of production, the number of accidents has been materially decreased.

It has been truthfully said that "The primary function of a safety organization is to educate, stimulate and develop, but the practical application of safety must be through the normal operating organization."

The foreman occupies a most important position in the operating department, as he is in direct contact with his men day after day. He is the "key man" and, in the eyes of his men, he is the boss and representative of the company. He is directly responsible for the work of his crew, not only as to production but also as to the safety of his men.

The National Safety Council in its lecture outline on "Reaching the Foreman" has said: "The workman's attitude towards safety depends absolutely on the attitude of the foreman. If he is indifferent, the men will be indifferent. But if he believes in safety, if by what he says and does each day he convinces his men that he is in earnest and is doing everything in his power to protect them, the foreman will get his men with him."

The successful foreman is one who really likes men and is on friendly terms with every man in his crew. He must be a leader and not a driver, so that his men work with him because they like it and not through fear of their jobs. The good foreman not only gives instructions as to the safe method of doing a job, but sees to it that such instructions are carried out. He will pay special attention to the new man and instruct him in the natural hazards of his job. He will not feel that his responsibility ends when he tells him to be careful. He knows that the new man is usually a bad risk. He recognizes that the safety of his men comes first and practices that principle in his daily work.

The foreman, in view of his position as the direct contact between men and management, should never be ignored in the matter of industrial relations. If he is worthy of his job, he should be supported and sustained by management and his authority fully recognized. It is the primary duty of management, however, to see that he is carefully instructed in the policies of the company and fully informed on any matter pertaining to the welfare and safety of his men.

Many serious accidents to new men are due to physical and mental defects which might have been discovered by proper examination. Such defects also account for the fact that some men are much more liable to injury than others. An applicant may be able to perform a certain job with safety to himself and his fellow men, but may be an absolute menace if permitted to try another job for which he is not physically suited. The choice of new applicants for jobs should not be made until they have undergone a thorough physical and mental examination to determine whether they have the necessary qualifications for the job. Periodic examinations of the entire working force should also be made for like reasons.

The days of hard gruelling labor in steel plants are practically a thing of the past and it is no longer necessary or desirable to hire a man simply because he has two good hands and unusual strength. The work which once required the services of a physical giant is now performed by machines. Due to shorter working hours and improved working conditions, the element of fatigue has been practically removed as a safety problem. It is more important today to examine the mental equipment of an applicant to determine whether he has the necessary education to do the work which may be assigned to him with intelligence and safety. Except in a very few cases, it would seem advisable to have a minimum requirement of a high school education or its equivalent.

Prompt and expert surgical attention saves many lives and often returns men to the job who would otherwise have been permanently and totally disabled. Training of men to report for treatment of minor cuts and bruises has resulted in the practical elimination of cases of infection. It is, therefore, essential to have an efficient and thoroughly trained medical and surgical staff, subject to immediate call for the care of emergency cases. A suitable emergency hospital is also a necessity.

First aid training schools have contributed much, in this latter respect, to the safety movement in the steel industry. In such schools classes of volunteer recruits from the working forces are carefully trained in all of the essential first aid practices and such trained men

scattered throughout the plants are able to render most valuable assistance in emergency cases.

THE FUTURE OF SAFETY WORK IN THE STEEL INDUSTRY

The question of continued and energetic accident-prevention work is especially important at the present time. Renewed industrial activity, with the attendant employment of many workers in tasks with which they are not familiar, will greatly increase the occupational hazards, even where conditions are rendered as safe as possible. Reduction or laxness in safety work will increase these hazards still further, exact their toll of injuries and suffering, and prevent efficient and economic operation of the industry. In this connection it is well to review what is being done in the industry today.

In a survey conducted by the American Iron and Steel Institute in 1935, in which 121 companies representing approximately 89 per cent of the total number of employees in the industry replied to a questionnaire on industrial relations subjects, it was found that 108 out of the 121 companies were conducting systematic programs of safety and accident prevention. Sixty-seven of the companies are members of the National Safety Council. All of them benefit from the educational program and other activities of the Council, and many of the companies are active in the work of the Council. It was found that 61 companies which are not members of the National Safety Council, nevertheless had systematic programs of safety and accident prevention in their respective plants. Twenty-nine of the companies which are members of the Council were not conducting a systematic program but were carrying on their safety work by means of the Council activities. Only 37 companies out of the 121 were without both systematic programs and Council memberships.

The survey mentioned above also showed that 41 companies guaranteed their workmen's compensation costs through self-insurance under state laws; 20 companies supported such costs through state funds; and 60 companies, with number of employees 10,000 or less respectively, guaranteed their workmen's compensation costs through private insurance companies.

In 76 of the 121 companies mentioned, the employees were regularly informed of the relationship between accidents and the rise and fall in compensation insurance costs.

With respect to the method of conducting safety and accident prevention programs, the survey showed that 108 companies covering 403,000 employees made use of safety posters and bulletins as a part of their safety program; 86 companies distributed safety literature; 82 companies held regular employees conferences on

TABLE II

Safety Practice in the Steel Industry, 1935

		Does your company or Corporation conduct a systematic program of safety and accident prevention? (1)	Is your workmen's compensation handled through an insurance company, or is the company a "self insurer?" (7)	Are employees informed of the relationship between accidents and the rise and fall in compensation insurance costs? (8)
I	1 to 250 Employees (38 Companies)	28 Yes 10 No	28 Insurance company 5 State insurance fund 5 Self insured	26 Yes 12 No
II	251 to 1,000 Employees (43 Companies)	40 Yes 3 No	28 Insurance company 10 State insurance fund 5 Self insured	29 Yes 14 No
III	1,001 to 10,000 Employees (30 Companies)	30 Yes	4 Insurance company 3 State insurance fund 23 Self insured	18 Yes 12 No
IV	10,001 to 25,000 Employees (7 Companies)	7 Yes	2 State insurance fund 5 Self insured	2 Yes 4 No
V	Over 25,000 Employees (3 Companies)	3 Yes	3 Self insured	1 Yes 2 No

safety; 75 companies had regularly organized safety committees in the various plants; 86 companies gave safety instruction on the job; 42 companies conducted regular inter-department competitions in safety and accident prevention; 34 companies gave safety awards for the best safety records or greatest improvement in safety ratings during the year; and 77 companies used disciplinary measures in their campaigns to eliminate accidents due to carelessness or neglect.

The above information is shown in greater detail in Table II.

What can be accomplished through a definite and intense safety program over and above whatever improvement may accrue from a lazy attitude in this matter, can be easily inferred from the following quotation from a report by the Department of Labor entitled "Accident Experience in the Iron and Steel Industry, 1934 and 1935."

"The experience of a select group of establishments with a large man-hour exposure presents a sharp contrast to that of the industry as a whole. This group's frequency rate of 6.3 for 1935 is less than one-third that of the industry as a whole. As against an all-industry decrease from the rate of 19.42 in 1934 to 17.14 in 1935, the rate for this group declined from 8.1 to 6.3.

"The establishments in this group have been interested in safety and accident prevention since about 1906. As the table shows, the frequency rate of 60.3 for 1913 had decreased to 23.1 by 1920, and by 1935 had reached the low figure of 6.3. If the injury experience of the industry as a whole had been as favorable as that of this group in 1935, there would have been only 5,006 disabling accidents instead of 13,622, or 8,616 fewer. Both groups produce a large variety of products, so that the big difference is not explainable on the basis of specialized processes."

While the record of the select group of plants, is somewhat better than that of the industry as a whole, it is nevertheless indicative of the general trend. It is interesting to note that the success of this particular group of plants in accident prevention work is attributed to the fact that their organized safety work began as early as 1906, and has been continued through the years with unabated vigor.

The mere recital of the "high spots" in the actual war against accidents in the iron and steel industry has served to point out the fundamentals of safety and accident prevention and shows clearly that safety has become a vital force in our industrial life. There will be little or no disagreement as to such fundamentals, but there may be considerable difference of opinion as to their relative importance in the work.

In our opinion the fundamentals, named in the order of their importance, are:

First: Proper attitude of our chief executives toward safety and their continued interest in safety.

Second: A safe place in which to work and safe working conditions.

Third: The foreman, with all that the word implies in this work.

Fourth: Careful choice of new employees, and their proper training.

Fifth: Safety organizations encouraged by top management.

Sixth: General educational program on safety for all employees.

Safety has built its house upon a rock, upon the solid foundation of public good and welfare. It has withstood all storms and overcome all reverses. The war against accidents is founded upon reason and common sense. It will go on, gathering power and momentum as it goes, until the unnecessary sacrifice of life and limb has been abolished.

The iron and steel industry may take real pride in the fact that its leaders had the vision, the courage, the interest and the common sense to bring the frequency of industrial accidents to public attention, to establish the industry as a pioneer in accident prevention work, and to maintain its position of leadership throughout the years.

We cannot rest upon our laurels, nor afford to become self satisfied. The battle must go on until all unnecessary accidents are eliminated. Safety demands the best thought and attention of every man in the industry from the highest to the lowest.

I suggest the following safety program to be sponsored by the American Iron and Steel Institute and to be put into effect as soon as possible in the interests of all members of the industry, and especially of those members which have not yet developed their safety programs to the highest possible standards, and I bespeak for this program the willing cooperation of all.

1. Give to the public the complete history of the safety movement and claim for the steel industry the full credit due for the leading part it has always taken and for the great advances that have been made. Cooperate with the National Safety Council in preparing the story.

2. Make a survey of the steel industry and determine which companies have well organized safety programs and which companies do not have such programs.

3. Appoint a safety committee and engage the services of a well trained safety engineer familiar with best practices in the steel industry. Develop a program of field work to secure 100 per cent cooperation of all companies in safety work.

4. When interest has been widely stimulated, stage a contest with offer of a prize for best performance in the industry. This would involve the keeping of special records by the Institute or by the National Safety Council.

5. Stimulate more interest in accident prevention by all members of the industry. Make discussion of safety a part of the program for all meetings of iron and steel men. Give more attention to safety in publications for the industry.

Provide a better interpretation of safety in the industrial and public relations policies of the industry.

Urge all companies to cooperate with the National Safety Council and benefit by its services.

In closing I would paraphrase the statement of the immortal Jefferson and say "Eternal vigilance of every man in the industry is the price of safety."

NEW CONTINUOUS ROD MILLS

American Steel and Wire Co.

JOLIET, ILLINOIS

▲ HIGH quality, low production costs and maximum output were the objectives set by the American Steel & Wire Company in building the two parallel continuous rod mills which are now completely installed and are being operated at Joilet. These mills, designed by the Wire Company's own engineers, embody all modern improvements and a number of new developments never before used in rod mills.

Every 40 seconds a No. 5 rod, nearly a mile long, comes off the final pass at a speed of 3428 ft. per minute, or approximately 40 miles an hour, as compared to 1500 ft. per minute in the old Joilet mills. Speed practically eliminates temperature drop in the rod during rolling and assures greater accuracy as to contour, and physical properties which improve wire quality and means greater safety in bridge and elevator cables and thousands of other products.

The new mill was dedicated June 23rd by prominent officials of the United States Steel Corporation and its Subsidiary, American Steel & Wire Company. C. F. Blackmer, President and C. F. Hood, Executive Vice-President, of the Wire Company were hosts to a group of leading business men and railroad officials from Chicago and Joilet on a tour of inspection through the new mills, following a luncheon with the Association of Commerce of Joilet. Heading the delegation from New York was Ralph H. Watson, Vice-President of the United States Steel Corporation, who along with Mr. Blackmer made the principal addresses at the local luncheon.

Part of a $5,000,000 development which includes improvements in the South Chicago and Gary billet mills, as well as the wire mills in Illinois, these new rod mills are capable of rolling the heaviest single bundle of No. 5 rod in the world. Although 600 lb. bundles, 5,000 ft. long, can be rolled by these mills, the regular bundle will weigh about 550 lb, and measure 4,375 ft. The two Joilet mills will have a combined capacity of 220,000 tons per year.

The rod mill buildings consist of two parallel bays 140 ft. wide by 408 ft. long with a 70 ft. wide hook conveyor building located parallel to the rod mill buildings.

Basic steel billets will be supplied from Gary Works and Bessemer billets from South Chicago Works of the Carnegie-Illinois Steel Corp. The billet yard is

General view of one of the new continuous rod mills of the American Steel & Wire Company, showing the roughing stands, the intermediate stands, the flying shear and the finishing stands.

General view of the driving side of one of the new continuous rod mills of the American Steel & Wire Company at Joliet, Illinois.

covered by a crane runway having a span of 120 ft., 415 ft. in length. This is served by two 15-ton capacity cranes which will unload the 2 5/16" square x 30 ft. long billets from the cars to storage. The yard is divided into a series of compartments, each having a capacity of about three carloads of billets, or a total capacity for the yard of approximately 20,000 tons. The compartments are numbered and a record of the stock in each is kept, so that the crane operator can be instructed to take billets out of a certain pile, according to whatever stock is required.

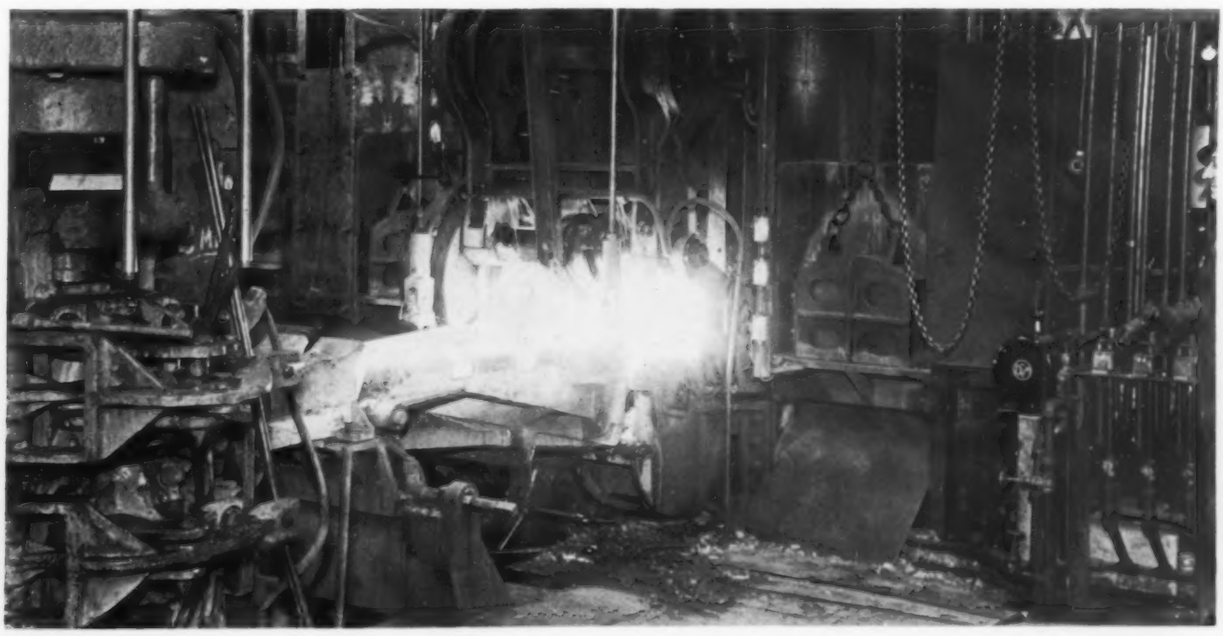
In the billet yard are located two skid platforms on which the billets are placed by the cranes and from these skids are rolled onto the furnace approach table. The furnaces have a hearth of approximately 32 ft. long x 34 ft. wide, and are heated by coke oven gas from the Carnegie-Illinois coke plant. They are designed, however, so that at any time either natural gas or oil can be used for fuel. Heathed billets discharge from the furnaces directly to the first stand of the two line continuous mills.

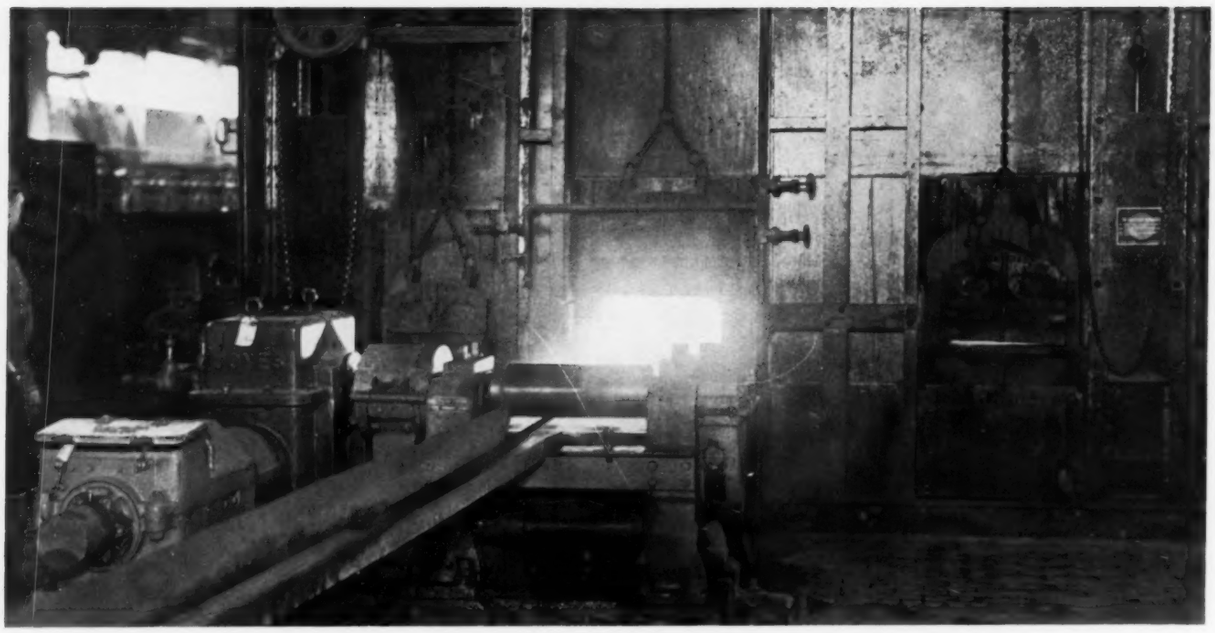
The two 19-stand continuous mills are built in parallel lines in the building at an elevation of approximately 14 ft. above ground level, which may appear unusual in mill construction. The reason for doing this is because the drainage conditions are such that if the mills were located on the ground level, as is usual, it would be necessary to pump all the water, containing scale, etc., to an elevation so that it could enter the existing sewers, the level of which was fixed by local conditions.

Each of the two mills, which are the first completely anti-friction bearing equipped rod mills ever built, consists of five 15" stands and four 13" stands, comprising roughing train, followed by steam powered flying shear for cropping the front end of the bar, and then ten 11" stands comprising the finishing train. The stands are equipped with tapered roller bearings with special provision for adjustment of the rolls vertically, horizontally and longitudinally, which permits lining up the passes accurately. In order to keep the mill in line it is equipped with universal spindles throughout instead of the usual wabblers. All the pinions of the roughing mill have herringbone teeth. Pinions in the finishing mill, together with their speed-up gears, which are arranged in the same case, have single helical teeth. The bevel gear drives are spiral and gear reduction sets have herringbone gears. Each mill is driven by a 4500 H.P. synchronous motor. Rolling speed at all stands is regulated so that the rod moves at a constant speed and under uniform tension, temperature drops being practically eliminated by the speed at which these new mills operate.

The billets to each mill are fed from the furnace in two lines. Starting with 2 5/16" square at No. 1 stand they are gradually reduced so that in making a No. 5 rod they leave the 19th stand .207" in diameter, 4375 ft. long, and at a speed of 3428 ft. per minute; or a total production from the two mills of 13,712 feet of rod per minute. As each rod leaves the mill it passes through a semi-automatic switching device which switches it to the different reels, six of which are provided for each mill. There is also located between the mill and the reels a descaling device which controls the scale left on the rods. In line with each mill and directly behind the reels is located the operating pulpit from which is controlled the starting and stopping of the mill, the switching of the rods from reel to reel, discharge of the rods from the reel to the conveyor, and the movements of the conveyor. The rods remain on this original drag

View of billets which are $2\frac{5}{16}$ in. square, 30 ft. long. The mills are both of two strands each, so that a pair of billets will pass through each mill simultaneously.





View of billet push out machine showing a billet out of the furnace. This furnace has a hearth 32 ft. long and 34 ft. wide, and carries a temperature in excess of 2000 degrees F. Furnace is designed so that at any time, it can be heated by either coke oven gas, natural gas or oil.

conveyor for a period of approximately 12 minutes, by which time they are cool enough to be handled on the hook conveyor.

Two hook conveyors are provided, one for each mill. One conveyor is considerably longer than the other, the intention being that the long conveyor will be used on the mill which will roll a variety of sizes to be used for special purposes requiring additional inspection and trimming before shipment. The mill with the short conveyor will roll a No. 5 rod at all times. It is expected that the entire capacity of this mill will be absorbed by the Company's own wire mills.

The hook conveyor is driven by an adjustable speed motor with such speed range as will give a movement of from 9 ft. to 27 ft. per minute. From the conveyor the rods are loaded by special cranes into cars for shipment. The arrangement of cranes is such that the rods are loaded so as to permit the easy unloading by means of crane and hook.

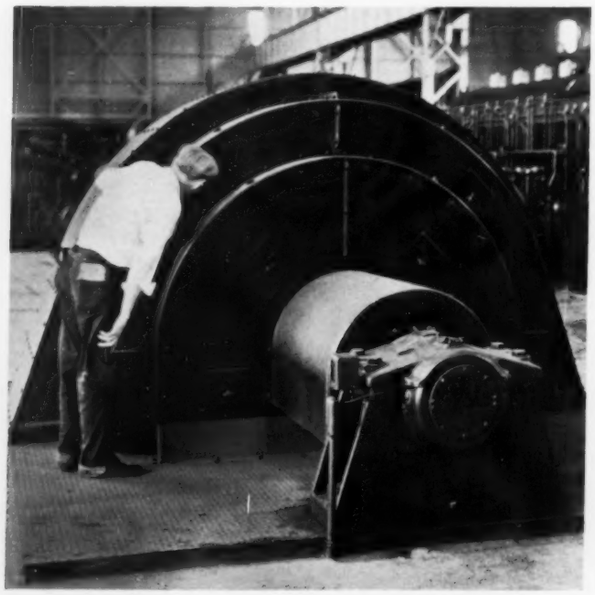
The mill is equipped complete with a special oiling system, which provides sight flows for all oil lubricated bearings and sprays to the gears. This system is located in the basement. Roll neck bearings are lubricated with grease.

Due to the fact that the mill itself is located 14 ft. above the ground level, space was available on the first floor for furnace recuperators, reel drives, electric controls, return conveyor chains, oil tanks, and all such equipment as was heretofore either placed on the mill floor or in balconies and pits.

Power for the mill is obtained from the local power companies and supplied to the main motors at 6600 volts. Direct current is supplied by a 4-unit motor generator set, one generator furnishing direct current for general use, the other two generators furnishing direct current power to the reel motors which must be run absolutely in step with the mill.

Water is obtained from the existing aqueduct. A new pump house was installed adjacent to the mill with two 6000 gallon per minute centrifugal pumps, either one of which will furnish all the water required by both mills. This water passes through a self-cleaning strainer to the mill service lines.

This 4,500 H.P. motor drives all of the rolls of the 19 passes in each double strand mill. Power for the mill is obtained from local power companies and supplies the main motor at 6,600 volts.



REGENERATIVE TYPE SOAKING PIT FOR USE WITH LEAN FUELS

▲ IT has been known for some time that blast-furnace gas would be an ideal fuel for heating ingots provided sufficiently high temperatures could be maintained when using this fuel to bring the ingots to the proper rolling temperature, and at the same time maintain the rated capacity of the soaking pit. It was also known that when heating ingots with blast-furnace gas the quality of heat was much better than when heating with high B.t.u. fuels, this being due to the properties of the gas itself. "Washing" the ingots was practically eliminated due to the low temperatures produced, and chipping costs reduced in some cases as much as 60%. Then again, blast-furnace gas is usually plentiful around a steel plant and is produced in such excessive quantities that much of it is wasted, thus resulting in loss of money.

In view of these facts, the Rust Furnace Company designed a new regenerative soaking pit for use with straight blast-furnace gas or other lean fuels such as mixed blast-furnace gas and coke-oven gas. The soaking pit is also so designed that it can use any other type of fuel which may be at hand, such as coke-oven gas, natural gas, oil, or producer gas.

A regenerative soaking pit designed for heating ingots with blast-furnace gas or any other lean B.t.u. fuel must be constructed with some device for preheating the air to extremely high temperatures, so that a correct flame temperature may be generated when using such gases. This device is nothing more than extremely large and deep regenerator chambers for regenerating the air only. The Rust soaking pit is constructed with regenerator chambers approximately 15′–0″ in depth and in volume approximately 900 to 1000 cubic feet of checker chamber per side of each hole. The checkers in most cases are so designed that the highest preheat possible is effected. Another important new feature is the use of complete automatic control. The soaking pit from the start of a heat to the finish is practically out of the hands of the operator. In order to accomplish this it was necessary to equip the soaking pit with the following controls:

1. Controls for automatically reversing the fuel, air, and waste gas valves and dampers.
2. Controls for automatically proportioning the fuel and air being burned.
3. Controls for automatically controlling the temperature in the soaking pit wherein the ingots are being heated.
4. Controls for automatically regulating the draft and consequently the pressure within the pit.
5. Controls for automatically closing all valves as the cover starts to open or in case there should be a power failure.

General view of soaking pits.

Control panel and instruments.

The new Rust regenerative soaking pit is so designed and constructed that each hole of each battery of pits is a separate and independent heating unit. Therefore, each hole can be operated and is operated as a separate furnace. The above mentioned automatic control devices are therefore provided for each hole, and operate as follows:

At predetermined intervals the time clock operates a program controller which breaks one electrical circuit and completes another simultaneously, performing the operations of reversal in the following sequence:

The gas valve leading to the side which has just been under fire is closed.

The air valve to this side and the stack damper on the opposite side are closed, and the air valve on the opposite side and the stack damper on the side which has just been under fire open.

When the proper damper is closed and the damper on what is now to become the outgoing side has opened to a predetermined point, the opposite gas valve is opened. Simultaneously, the stack damper which has just been opened is connected to the stack draft regulator and immediately assumes the proper position to maintain the correct pressure within the pit.

In order to conserve the heat within the pit and regenerators when the cover of each hole is opened, and in order to provide an absolute safety feature should there be a power failure, a device is provided for closing all valves as the cover starts to open or if there should be a complete power failure. By means of a push button on the panel board, the pit can be dampered down completely for soaking or placed under fire.

Should the soaking pit become out of balance, that is, one regenerator hotter than the other, it is possible to adjust the time cycle by simply setting the time clock so that the reversal can be quicker or slower for one side or the other, as is desired.

In order to always maintain the proper and exact temperature within the soaking pit wherein the ingots are being heated, an automatic temperature control mechanism is provided —which consists of a Rayotube thermocouple in the cover complete with Leeds & Northrup or Brown recording controller — which opens and closes the fuel valve supplying the gas or the fuel to each hole. As the fuel valves open or close, the fuel-air ratio control mechanism causes the air valves to open or close accordingly in order to maintain the proper ratio of fuel and air.

The final results of the new Rust regenerative soaking pit as described have far exceeded expectations. This pit is giving a higher capacity with better quality of heat and less fuel consumption than any soaking pit now in existence.

WELDING PROCESS REDUCES WEAR

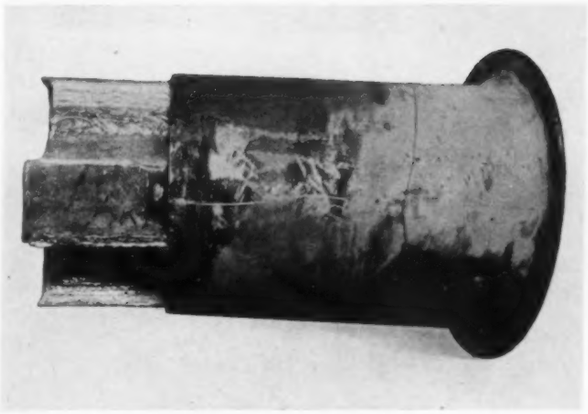
▲ HARD-FACING, the protection of wearing surfaces of machinery and other equipment by welding on a layer of hard, wear-resistant alloy, as developed by the Hayes Stellite Company, has proved to be a most economical maintenance process throughout the steel industry. Hard-faced parts have long been employed in blast furnace plants, coke and gas plants and in open hearth plants, but many of their most important and effective applications are found in rolling mills. From the soaking pits all through the mill—guides, journals, spindles, and special rolls—this process plays an important part in assuring economical production.

The savings gained by hard-facing result principally from the reduction in replacement of worn parts, but other savings are also apparent. Machine parts can often be made less expensively if fabricated of steel hard-faced on only those surfaces to be subjected to extreme abrasion or heat. The non-ferrous hard-facing alloy most generally employed is both hard and wear-resistant even at elevated temperatures. For this reason even such conditions as are encountered in the abrasion of roll guides by hot steel are adequately met and withstood by guides hard-faced with this alloy. In addition, the alloy has a low coefficient of friction and does not pick up particles of steel. Thus, it is also satisfactory for many special designs of rolls.

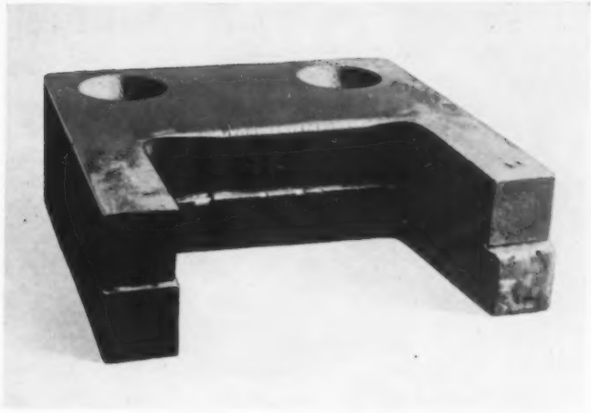
For example, diagonal rolls for taking up the stretch in rolling structural steel, wear rapidly where the flanges of the beam dig into the rolls. By machining recesses at these points approximately 3/16-in deep and 4½-in. wide, and filling these recesses with a layer of hard-facing alloy flush with the surface of the roll, the life of the rolls may be extended to over four times that of plain steel rolls.

Side guides in rail mills in contact with the ball surface of the rail also are subjected to very severe abrasion. Completely or partially surfaced with a cobalt-base alloy, depending upon the type of mill, the guides can be made to last several months as against an average life of one week for plain cast steel guides.

Flying shears as well as stationary blades for shearing squares and



Five times its former life was obtained by hard-facing this spindle.



Top—plain steel shear blade after shearing 6 heats of 4 to 5 billets. Bottom—Haynes Stellited shear knife after shearing 50 heats.

rounds have been successfully hard-faced. Since the alloy of cobalt, chromium and tungsten generally employed retains its hardness at red heat, it is especially adaptable for such service. One hundred kegs of 1⅛-in. square nuts is the average production of regular steel blades, as compared to an average of 1,500 kegs with hard-faced shears. Flying shear blades of 0.50 per cent carbon steel, hard-faced with this alloy, have sheared 54 heats of 4-in. billets. The blades formerly used sheared an average of but 6 heats. These blades can be built up over and over again at but a small expense for applying the wear-resistant metal and grinding.

Conveyor rolls and shafts in reheating furnaces naturally cannot be lubricated. Operating at a temperature of approximately 750 deg. F., any lubricant would be immediately burned out. A metal must be used which neither requires lubrication nor is affected by this temperature. In one plant, hard-facing metal was applied to the roll and shaft bearing surfaces. After a few experiments the correct size was soon found to allow the proper clearance. The bearing showed no signs of wear whatsoever after four months of service.

A spindle for a 24-in, mill was hard-faced on each end and on both sides of the pad. Not only did it give an increase in life of 5 to 1 over former steel spindles, but great savings were effected indirectly by reducing backlash of the gears. Reversible blooming mill spindles have also been given greater service life by hard-facing. In addition, blooming mill shear clutches, wearing rings in bar mills, gag press hammers, edging rolls, and innumerable other parts are more efficient if hard-faced.

At a large steel plant in the Middle West, the points of grapling tongs for raising hot ingots from the 40-in. blooming mill soaking pits were recently surfaced with a heat and abrasion-resistant alloy. The thin layer of an alloy of cobalt, chromium and tungsten has proved to be very

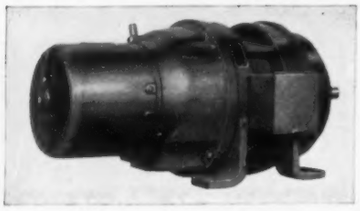
A sleeve gear for driving an edging roll; the 14 teeth are rebuilt and resurfaced with hard-facing material.

economical—a saving of over $10,000 a year has been made on this application alone. Where, formerly, 19,000 bits were kept on hand continually, a large reduction in inventory is possible, since tong bits with hard-faced points last over six times as long as new steel bits. Naturally, the mill has standardized on hard-faced bits.

Mill superintendents, endeavoring to make their plants more productive have effected substantial economies by the use of the hard-facing process. Costly replacements with new parts can be put off indefinitely, because the application of hard-facing material can be made repeatedly. The frequency of expensive shutdowns is very appreciably reduced, due to the longer service life of the special metal surface. New part inventories can be reduced, and machinery made to run more smoothly and effectively for a longer period of time. With these many advantages, the application of the hard-facing process has become standard practice in mills where steady, more efficient, production is desired.

DISC-BRAKE MOTOR

▲ A NEW power unit, known as the "disc-brake" motor, is now made available by The Reliance Electric & Engineering Co., 1088 Ivanhoe Rd., Cleveland, Ohio. It combines in a single unit the functions of a motor with those of a powerful brake, and is useful for small cranes, hoists, auxiliary movements on machine tools and other equipment in which quick, automatic and accurate stopping or the holding of a load is necessary. It is stated that with these disc-brake motors it is often possible to connect the drive direct and thus to avoid the need for clutches. Reliance motors of any operating characteristics, both D.C. and A.C., may be specified to meet any particular case. The brake itself consists of a simple and compact disc-type friction device, mechanically and automatically engaged when the current is shut off and magnetically disengaged when current is applied. The friction lining is supported on a square steel hub which is keyed to the motor shaft.



Disc-Brake motor for use on small cranes, hoists, and other equipment that requires quick automatic stopping.

A "wear-indicator", combines with the manual brake release mechanism, giving warning whenever wear needs to be taken up. This setting, however, is separate from the torque adjustment, so that either may be adjusted independently. Varying braking power, from maximum to 50% of maximum, may thus be obtained as needed. The brake mechanism operates equally well in any position, and may be fitted to any standard Reliance motor except those of the fan-cooled type. All mounting dimensions conform to N.E.M.A. specifications so that standard brackets and bases may be used. The brake cover, which is entirely separate from the mechanism itself, may be readily removed by loosening four cover screws, thus making all parts easily accessible.

GULF STATES DIVISION OF REPUBLIC EXPANDS

▲ REPUBLIC Steel Corp. has announced a $2,000,000 expansion program for its Gulf States Steel division.

Two 150-ton open-hearth steel furnaces costing $750,000 will be added, increasing its open-hearth capacity 50 per cent.

Sheet mill capacity will also be increased 50 per cent, $1,000,000 being spent in this department.

The Nashville Bridge Co. has been awarded a contract for an open-hearth building extension at $150,000.

The Morgan Engineering Co. and the Alliance Engineering Co. have been awarded contracts for machinery and cranes totaling $200,000. These include two 110-ton ladle cranes, a 75-ton charging crane, a charging machine, and additional facilities for stripping and preparing ingot molds.

MILLION DOLLAR BLAST FURNACE

▲ THE new million-dollar blast furnace being erected by The Hamilton Coke & Iron Company near Hamilton, Ohio, will be ready for operation early in August, according to J. A. B. Lovett, vice-president and general manager of the company. Work on the furnace was started in December, 1936.

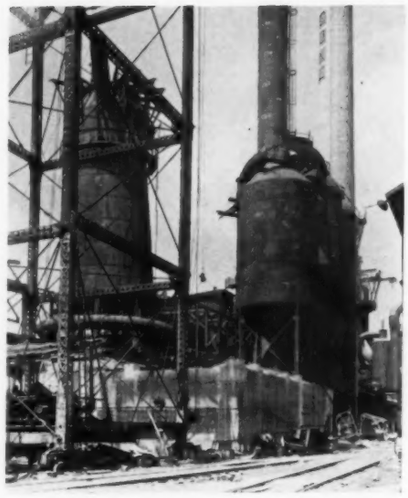
The Hamilton Coke & Iron Company is a completely owned subsidiary of The American Rolling Mill Company, Middletown, Ohio. Located only ten miles from one of Armco's chief plants, it supplies molten pig iron to the open hearth furnaces. A special train transports the liquid metal in huge "thermos bottle" tanks.

Completion of the new furnace will give the company a daily capacity of about 1200 tons of pig iron. The present furnace, which was completely rebuilt and modernized last year, has a capacity of more than 700 tons a day.

Addition of the second blast furnace is for the production of Buckeye foundry iron, as the product is known. To provide ample supplies for the new unit, the ore yard has been improved and enlarged. Many new bins have been constructed to provide service to the furnace direct from the ore yard. In normal operations in the manufacture of merchant pig iron, many different grades of iron ore are needed to supply all the various grades of foundry iron the trade demands. The new furnace has a hearth thirteen and one-half feet in diameter and is capable of producing more than 450 tons of merchant pig iron a day.

Construction features include the most modern developments in present day blast furnace engineering. Iron ore and all other raw materials are automatically charged into the mechanical top by a skip hoist. The mechanical top is so constructed as to thoroughly distribute the ores in the furnace. This feature makes possible an unusual degree of uniformity in the manufacture of merchant pig iron.

All auxiliary equipment is of the latest type. The furnace is equipped with primary dust catchers, wet tower gas washers, and an electrical dust precipitator which removes from the gas all but .015 grains of dust per cubic foot. This provides extremely clean gas for underfiring the three large capacity hot blast stoves, which will maintain 1600 to 1800 degrees of heat.



Million dollar blast furnace which is nearing completion at the Hamilton Coke and Iron Company.

TOTALLY ENCLOSED FAN TYPE MOTOR

▲ THE type CP motor as manufactured by the Wagner Electric Corp., meets the long standing demand for a totally-enclosed sealed unit for driving equipment which must be operated in atmospheres heavily laden with abrasive dusts, deteriorating metals and salts, explosive dusts, corrosive gases and extreme dampness on out-of-door applications. Thousands of these

Totally enclosed fan cooled motor for driving equipment that must be operated in atmospheres laden with abrasive dusts and corrosive gases.

motors are now operating successfully in chemical plants, foundries, automobile factories and oil fields which prove that they meet these requirements.

This motor consists of a skeleton type stator, deeply grooved on the outside to increase radiation, which is provided with totally-enclosed ball bearing endplates with long machined fits to completely seal the working parts of the unit. An external blower is mounted on the front end which directs cooling air around the front endplate and over the corrugated surfaces and through a baffled back endplate down over the bearing. The movement of the air is directed over these surfaces by special blower and frame shields. The shaft of this motor is made of special alloy steel for strength and has machined fillets at all changes of diameter to prevent fatigue. The ball bearings are all of the cartridge type and are of the same diameter on both ends to permit double shaft extensions of the same diameter. The front end bearing carries the thrust while the back bearing is of the floating self-aligning type. The cartridges are normalized before machining in order to obtain very close tolerances. They are also designed so that complete lubrication can be carried out during operation. No cored holes are used for introducing grease, eliminating contamination of grease by foundry sand. The caps of the cartridges are also specially designed to prevent entrance of water along the shaft. The endplate on the back end is of the one-piece deflector type to aid in keeping the bearing cool. Both endplates are provided with threaded air gap holes to make air gap checking an easy task. The core of these motors is in the center of the frame to permit reversing of the endplates and rotor in order to reverse location of conduit box. The feet are electrically welded on to the frame and are made of unbreakable steel. All coils are wound with cotton-covered double-enameled wire with all free ends taped well into the slots. All coils are insulated from core by heavy fibre slot insulating material.

NEW BOOKLETS AND CATALOGS

▲ THE Whiting Corporation announces a new pamphlet No. 221, describing the new Whiting Tiger Skip Hoist Charger for Cupolas. This booklet may be obtained by writing the Whiting Corporation, Harvey, Illinois.

▲ SURFACE Combustion Corporation has just issued a new booklet entitled, "Modern Annealing Practice" which illustrates both by photographs and blueprints six different forms of radiant tube annealing covers for sheet strip, rod and wire. In addition, there is in this booklet an illustration and brief description for manufacturing the prepared atmosphere used with these annealing covers. The address of this company is Dorr Street, Toledo, Ohio.

▲ BULLDOG Electric Products Company have available a 24-page bulletin describing the Bustribution System of Electrical Distribution. Copies may be obtained by writing the Bulldog Electric Products Company, Detroit, Michigan.

Bustribution is the modern, enclosed method of electrical distribution which permits circuits to be "plugged-in" where and when required. It provides a highly flexible system in which changes or additions may be made at any time.

In planning or laying out an electrical distribution system it is not always possible to anticipate just what future requirements may be necessary. With conventional wiring systems any later changes or additions to the initial layout always involves considerable expense and usually costly delays.

Bustribution however, while limiting the initial cost to immediate requirements, has economical provisions for adding additional branch circuits or extending feeder lines as additional loads or changes in loads necessitate.

▲ THE Okonite Company of Passaic, New Jersey, manufacturers of Insulated Wires and Cables, have published a new and revised edition of their book, "Splices and Tapes", which is available upon request. Various chapters in this booklet cover such subjects as "The Importance of A Perfect Splice"; "Requirements for a Splicing Compound"; "Requirements for Adhesive Tape"; and "Instructions for Joining".

▲ A compact presentation of the Worthington line of vertical single-cylinder single-stage air-cooled and water-cooled compressors is offered in an illustrated eight-page bulletin.

Sectional views showing important features of construction, detailed specifications of the feather-type valves and other principal elements, rating tables, and dimension tables, are included.

Bare compressors, and base-mounted units with motor and V-belt drive, are covered in the tables. Illustrations show also units complete with vertical or horizontal air receiver, direct-connected to electric motor, direct-connected to gasoline engine, and three-cylinder and six-cylinder angle-type two-stage units in various arrangements.

Ask for Bulletin L-621-B5. Address Worthington Pump and Machinery Corporation, Harrison, New Jersey.

61 NEW COKE OVENS FOR FORD

▲ FORD Motor Co. has awarded to the Koppers Co., Pittsburgh, the contract for constructing an additional battery of 61 by-product coke ovens at the Rouge plant.

Cost of the new ovens and accessory equipment will be $1,750,000, of which the Koppers contract totals $1,200,000.

This new battery is intended to increase the present supply of fuel gas 25 per cent or to 40,000,000 cubic feet daily, much of it to be used for melting and heat treating furnaces.

The new ovens will yield 1125 tons of coke daily and will increase production of coal tar by-products 25 per cent.

When this addition is completed next summer, Ford will have 303 by-product ovens.

LEWIS FOUNDRY ADDS NEW EQUIPMENT

▲ THE Lewis Foundry & Machine Company, subsidiary of the Blaw-Knox Company, has enlarged its manufacturing facilities and increased its total floor space approximately 50 per cent. Additional, modern machinery being installed includes roll grinders, boring mills, and gear cutting machinery.

ITEMS OF INTEREST

M. D. Howell, of New York, has been made a vice president of the Carnegie-Illinois Steel Corporation, effective August 15, 1937.

A graduate of the University of Michigan in 1912, Mr. Howell is 49 years of age. He received a degree in business administration and included all law school courses on business and corporation law. He is a public accountant, certified by the state of New York.

From 1912 to 1919 he was traveling auditor and special accountant of the American Telephone and Telegraph Company.

He was president of the Southern Saw Works, Atlanta, Ga., from 1919 to 1921, re-organizing and rebuilding a circular saw factory.

As chief accountant of the Ohio Bell Telephone Company, Cleveland, from 1921 to 1924, Mr. Howell effected the consolidation of two large telephone properties, organized accounting and statistical work and developed control records and reports.

As senior auditor of Lybrand, Ross Brothers and Montgomery, of New York, from 1924 to 1926, Mr. Howell's work was concerned with the auditing and accounting work involving corporate re-organizations, refinancing and accounting systems.

From 1926 to 1928, he was accounting consultant, associated with the New York law firm of Beekman, Bogue, Clark and Griscom, as an advisor on accounting and tax problems in connection with corporate financings and re-organizations.

From 1928 to 1930, he was comptroller of the Postal Telegraph and Cable Company, subsequent to acquisition and control of that company by the International Telephone and Telegraph Company.

▲

Frederic B. Quigley has been appointed general superintendent of the combined Farrell Works of the Carnegie-Illinois Steel Corporation, which is composed of the Farrell Steel Works and the Farrell-Mercer Sheet and Tin Mills.

Mr. Quigley entered the steel industry in the blast furnace department of Carnegie Steel Company's Ohio Works in 1908, year of his graduation as a metallurgical engineer from the Case School of Applied Science. He was appointed assistant superintendent of the department in 1912, and was later promoted to the position of superintendent of the open hearth and bessemer departments. He was named assistant general superintendent of the Youngstown district in 1927, and continued in that position until 1935. Shortly after the merger of the Carnegie and Illinois Steel Companies, Mr. Quigley was made general superintendent of the Farrell Steel Works and Furnaces, the position he now occupies.

▲

C. A. Ferguson was made the assistant general superintendent of the Farrell Works, Carnegie-Illinois Steel Corporation, in charge of sheet and tin plate.

Mr. Ferguson, a 1911 graduate of the University of Michigan, was a draftsman for the Westinghouse Electric and Manufacturing Company from 1912 to 1913. That same year he became assistant master mechanic at the Vandergrift Works of American Sheet and Tin Plate Company. Six years later he was appointed master mechanic at the Farrell Works of the sheet and tin company and in 1927 was promoted to assistant managership of the plant. He continued in that position when the Farrell and Mercer plants were combined. He was made manager of the Farrell-Mercer Works in 1935. When the sheet and tin plate company was combined with Carnegie-Illinois Steel Corporation, Mr. Ferguson was named general superintendent of Farrell-Mercer Works.

▲

G. W. Humes was appointed assistant general superintendent in charge of all steel mill operations of the new Farrell Works of the Carnegie-Illinois Steel Corporation.

Mr. Humes attended the Pennsylvania State Col-

M. D. HOWELL

FREDERIC B. QUIGLEY

HARVEY DEMMON

NORMAN J. QUINLAN

GLENN W. COVALT

E. W. TREXLER

lege and entered the employ of Carnegie Steel Company as a machinist helper at Farrell in 1908. He later transferred to the open hearth department where he successively learned the duties of slagger, helper and melting foreman. He was an assistant open hearth superintendent with Bethlehem Steel Corporation for three years, and returned to the Farrell open hearth in 1920. He was named assistant open hearth superintendent there in 1920 and was promoted to department superintendent in 1929. Mr. Humes was open hearth superintendent at Farrell for eight years.

▲

Charles Cricks, formerly assistant superintendent of the open hearth department, Farrell Works, Carnegie-Illinois Steel Corporation, was appointed superintendent of the open hearth department, effective July 1, succeeding G. W. Humes.

▲

A. A. Dow, now in the office of E. T. Barron, manager of the metallurgical department for the Pittsburgh district, was transferred to Farrell on July 1, as assistant to the superintendent of the open hearth, Farrell Works, Carnegie-Illinois Steel Corporation.

▲

Harvey Demmon has been appointed superintendent of maintenance of the Farrell Works of Carnegie-Illinois Steel Corporation.

Mr. Demmon assumed the duties of his new position when the present Farrell Steel Works and Furnaces and the Farrell-Mercer Sheet and Tin Mills were merged and operated as a single plant on July 1.

Associated with the sheet and tin plate producing subsidiary of United States Steel Corporation for 17 years, Mr. Demmon was master mechanic at Farrell-Mercer Works.

Mr. Demmon was graduated from Purdue University as a mechanical engineer and was in construction work for three years prior to his employment in the steam engineering department at the general office of the American Sheet and Tin Plate Company on February 1, 1920.

He was assistant resident engineer at the Vandergrift Works of the company from March 1, 1924 until March 1, 1935, when he was appointed master mechanic at the Farrell-Mercer Works.

The sheet and tin company merged with Carnegie-Illinois Steel Corporation on June 1, 1936, Mr. Demmon's service as master mechanic at the Farrell-Mercer Works being continuous to date.

▲

Norman J. Quinlan, formerly superintendent of production and processing contracts, has been appointed assistant to general superintendent of Gary Works of the Carnegie-Illinois Steel Corporation.

Mr. Quinlan has been associated with Gary Works since 1908 having served in the construction department, the merchant mill, and the order department.

▲

Glenn W. Covalt, who was formerly chief clerk to the assistant general superintendent, succeeds Mr. Norman J. Quinlan as superintendent of production and processing contracts.

Mr. Covalt came to Gary Works in 1912 where he was employed in the merchant mill and held several operating positions before he became chief clerk to the assistant general superintendent in 1918.

▲

E. W. Trexler, formerly superintendent of the steam and combustion department, has been appointed superintendent of maintenance of the Bethlehem Steel Company, Johnstown, Pennsylvania. Mr. Trexler succeeds the late W. E. Miller. Mr. Trexler is an active member of the Association of Iron and Steel Engineers.

▲

W. P. Marquis has been appointed works auditor of the new Irvin Works of the Carnegie-Illinois Steel Corporation.

Mr. Marquis formerly was chief of the bureau of costs at the company's general offices here. He has been employed by subsidiary companies of United States Steel Corporation since 1913, when he was an

DONALD C. BAKEWELL

MALCOLM F. JUDKINS

DWIGHT G. PHELPS

accountant at the Shenango Works of the then American Sheet and Tin Plate Company.

Following a year with the ordinance department of U. S. Steel at Neville Island in 1918, Mr. Marquis was transferred to the Gary, Ind., tin mill where he later served as chief accountant for five years. He entered thc bureau of costs in the local offices of the sheet and tin plate company in 1929 and in 1932 became chief of the bureau. He continued in that capacity until consolidation of the sheet and tin company with Carnegie-Illinois in June, 1936. He was at that time named chief of the bureau of costs of the combined companies and served continuously until his recent appointment.

▲

Donald C. Bakewell has resigned as vice president and chairman of the executive committee of the Continental Roll and Steel Foundry Company, in which capacity he has served since 1930, to become vice president of the Blaw-Knox Company. He will make his headquarters in the executive offices at Pittsburgh.

He is a graduate of Yale University of the Class of 1908. After two years postgraduate work at Massachusetts Institute of Technology, he was a special apprentice for the Pennsylvania Railroad at Altoona, Pa. From 1911 to 1917, he was connected with the Duquesne Steel Foundry Company as machinist, tool maker, assistant superintendent, assistant secretary, and secretary. In 1917, Mr. Bakewell was made president of this company and served in that capacity until the merger with Continental Roll and Steel Foundry Company in 1930.

▲

Malcolm F. Judkins has been appointed chief engineer of the Firthite Division of the Firth-Sterling Steel Company of McKeesport, Pennsylvania.

Mr. Judkins was graduated in chemical engineering from the University of Washington in 1928 and received his Master of Science degree from Carnegie Institute of Technology in 1929. He has also taken special courses at Carnegie-Tech in machine shop and management engineering.

Mr. Judkins is also chairman of the American Society of Mechanical Engineers, Sub-Committee on Metal Cutting Materials. He has been identified with engineering work in the Firthite manufacturing department since the beginning of the sintered carbide development.

▲

Dwight G. Phelps, as announced by the Colt's Patent Fire Arms Manufacturing Company, Hartford, Connecticut, has been made the vice president of the company, in charge of the electrical division. Mr. Phelps has been associated with the Colt firm since he graduated from the Hartford public schools in 1902.

His career with the Colt company started with the duties of office boy from which elementary work he was soon relieved to take on more exacting duties of the sales department. The World War brought added responsibilities to him and in 1924 he was promoted to the position of general sales manager. In 1929 when the Colt company set up its four divisions to give its diversified products the attention they required, he became manager of the electrical division which position he has held until this time. Mr. Phelps has been an active member of N. E. M. A. for several years, serving as vice-president in 1934.

▲

H. W. Fitzgerald, who recently left the Lackawanna plant of Bethlehem Steel Company to assume the position of assistant chief engineer, Corrigan-McKinney division of Republic Steel Corporation, Cleveland, has been advanced to chief engineer of that division. He succeeds J. H. Van Campen, who resigned and is now associated with the H. A. Brassert Company, Chicago, Illinois.

▲

Henry L. James, manager of rolling mills and foundries, Pencoyd Works, American Bridge Company, retired on May 31, 1937, after more than 48 years of service with this company. His co-workers honored him with a dinner on June 19, at the Penn Athletic Club, Philadelphia ,Pennsylvania. Mr. James was born in Wales and immigrated to America

with his family in 1886. He was educated in the public schools of Allentown and Philadelphia, and at night attended the Central High School and the Franklin Institute of Philadelphia.

In 1885, Mr. James secured employment as a roll turner with the Hughes and Patterson rolling mills, remaining with that firm for three years. December 15, 1888, Mr. James was employed as a roll turner under John R. Jones by the A. and P. Roberts Company, at which occupation he was engaged for two and one-half years. At that time, he was transferred to the drawing room under James Christie, mechanical engineer, and worked in that department as a mechanical draftsman until he was appointed roll designer and superintendent of roll department on May 19, 1900, succeeding John R. Jones. In April 1919, Mr. James was appointed assistant manager of Pencoyd rolling mills of the American Bridge Company, and on April 1, 1921, he was appointed manager of rolling mills and foundries, Pencoyd Works, American Bridge Company, succeeding Mr. Charles Major.

▲

Forrest U. Webster has resigned as merchandising sales manager, Cutler-Hammer, Inc., Milwaukee, manufacturer of electrical controls, to join the staff of Lord and Thomas, New York, the latter part of June.

FORREST U. WEBSTER

Mr. Webster joined Cutler-Hammer in 1925 as advertising manager and was advanced to his present position in 1934. He is well known for his activity in the industrial advertising and marketing field, having served as president of the National Industrial Advertisers Association in 1932-33 and as president of Milwaukee Association of Industrial Advertisers in 1929-30.

Mr. Webster has been active in the National Electrical Manufacturers' Association for many years, now heading the advertising and publicity committee and the enclosed switch section and serves as a member of the business development committee.

His first industrial advertising work was with the H. W. Caldwell Company, now a part of Link-Belt Company, where he advanced from office boy to advertising manager. Later he was in the advertising department of Standard Oil Company of Indiana and subsequently had agency experience with the Irvin F. Paschall Agency, Chicago.

▲

H. F. Boe has been appointed commercial manager of the Westinghouse Electric and Manufacturing Company.

Mr. Boe will have two headquarters, one in the Union Bank Building at Pittsburgh, the other at 150 Broadway, New York.

In addition to being responsible for the sale of Westinghouse products in the Eastern District, Mr. Boe will now direct the commercial activities of the apparatus divisions.

A native of Mansfield, Ohio, Mr. Boe has been associated with Westinghouse since 1900. His studies included engineering courses at the Casino Institute of Technology and Carnegie Institute of Technology.

▲

Frank P. Dahlstrom has joined the staff of The Aetna-Standard Engineering Company, where he will fill the position of electrical engineer.

Mr. Dahlstrom has specialized in the electrical field, but has accomplished notable work in the mechanical field, having designed the now world famous oil lubricated bearing for use on mill roll necks. This patented bearing has resulted in reducing power requirements by as much as one-half in certain types of mills.

▲

D. D. Pendleton, for many years associated with Wheeler Condenser and Engineering Company and Power Specialty Company, now merged into Foster Wheeler Corporation, has resigned as their Pittsburgh District Manager and has opened an office at 2418 Koppers Building, Pittsburgh, Pennsylvania.

Mr. Pendleton is arranging to again act as Manufacturers' Agent—representing various Manufacturers of Oil Refinery and Power Plant Equipment.

▲

Died

William T. Martersteck, 67, prominent in the steel industry of Canton and Youngstown, O., and Sharon, Pa., districts, in Cleveland, June 21. Born in Bruggen, Germany, he was educated there and came to America at the age of 20. He was chief engineer in charge of constructing the Central Steel plant at Massillon, O., now the alloy division of Republic Steel Corp., and the Mark plant, Indiana Harbor, Ind., now a division of Youngstown Sheet & Tube Co. For three years ending in 1931 he was engaged on construction work in Russia, first for the Freyn Engineering Co. and later for the Soviet government direct.

▲

John Mordecai, superintendent of the wire division of the Sparrows Point plant of Bethlehem Steel Corp., died July 2, in a hospital at Baltimore. He had been ailing for some months, but exerted himself to complete construction of the new wire mill. He was a former president of the Wire association.

ADVERTISING PAGES REMOVED

CROUSE-HINDS
Type MK
SAFETY
SWITCH CONDULETS
For Continuity of Service

The points of greatest likelihood of interruption are at the switching devices, as they are placed at convenient points and usually operated by persons who have little or no knowledge of electricity or of the results which may occur because of their carelessness in handling these devices. Such being the case, it is necessary to enclose or protect all live parts so that they cannot be damaged. Yet in doing this, it must be borne in mind that all of the working parts must be accessible to authorized persons, for inspection and repairs.

The MK series Condulets consist of a line of fusible knife switches in cast Feraloy housings, operated by an outside handle. The door over the fuse compartment gives access to the fuses, but as this door is interlocked with the handle, the fuses are accessible only when dead.

A Nationwide Distribution Through Electrical Wholesalers

Condulet Catalog No. 2500 will be sent on request.

CROUSE-HINDS COMPANY
SYRACUSE, N. Y., U. S. A.

Sales Offices: Atlanta — Boston — Chicago — Cincinnati — Cleveland — Dallas — Detroit — Kansas City — Los Angeles — Milwaukee — Minneapolis — New York — Philadelphia — Pittsburgh — San Francisco — Seattle — St. Louis — Washington